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Bulletin 66

DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
JOSEPH A. HOLMES, DIRECTOR

TESTS OF PERMISSIBLE EXPLOSIVES

BY

CLARENCE HALL
AND
SPENCER P. HOWELL

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TESTS OF PERMISSIBLE EXPLOSIVES.

By Clarence Hall and Spencer P. Howell.

INTRODUCTION.

The tests and studies begun by the United States Geological Survey in the fall of 1908 with a view to lessening the accidents attending the use of explosives in coal mining are being continued by the Bureau of Mines at the Pittsburgh experiment station and in the field. One hundred and six applications for the testing of 209 different explosives had been received at the Pittsburgh station prior to March 1, 1913, and on that date 97 explosives that had passed the required tests were on the "permissible" list issued by the bureau. This bulletin gives the results of tests of all permissible explosives tested between May 15, 1909, and March 1, 1913. Bulletin 15 entitled "Investigations of Explosives used in Coal Mines" contains the results of tests of 17 permissible explosives tested prior to May 15, 1909. A copy of the test requirements and the names of explosives on the permissible list dated March 1, 1913, are appended to this bulletin.

An explosive is considered permissible for use in coal mines when it is similar in all respects to the sample that passed the tests required by the bureau, and when it is used in accordance with the conditions prescribed.

The physical tests reported in this bulletin were conducted by Messrs. H. F. Braddock, A. J. Strane, J. W. Koster, A. S. Crossfield, A. J. Hazlewood, A. B. Coates, and J. E. Tiffany at the Pittsburgh experiment station of the bureau.

The act of Congress making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1912, authorized the Secretary of the Interior to charge a fee covering the actual necessary expenses involved in making such tests by the Bureau of Mines as might be approved by him. After careful consideration had been given to the actual necessary expenses involved in the testing of explosives to determine their permissibility for use in coal mines, the sum of $150 was approved by the Secretary of the Interior as a reasonable charge for each complete official test.[a] During the first year this law was in effect the fees collected amounted to more than $6,000.

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[a] Fees for testing explosives and conditions under which explosives will be received for test, Schedule 1, Bureau of Mines, 1913.

YEARLY SALES OF SHORT-FLAME EXPLOSIVES.

In the past few years there has been a rapid increase in the use of short-flame explosives in the coal mines of the United States. The following table shows the quantities of such explosives sold during each year from 1901 to 1912, inclusive:

Yearly sales of short-flame explosives in the United States, 1901–1912.

Year.	Quantity sold.	Year.	Quantity sold.
	Pounds.		*Pounds.*
1901		1907	2,095,244
1902	11,300	1908	2,108,610
1903	288,661	1909	8,942,857
1904	608,270	1910	11,820,836
1905	1,031,300	1911	13,428,239
1906	1,533,575	1912	18,149,977

Unlike Government bureaus in some foreign countries, the Bureau of Mines has no authority to compel the use of certain explosives or to prescribe the conditions under which they must be used. Nevertheless, through the cooperation of State mine inspectors, manufacturers of explosives, coal operators, and miners the explosives that have been tested by the Bureau of Mines and designated permissible explosives are now used in every coal-mining State.

QUANTITY OF PERMISSIBLE EXPLOSIVES SOLD IN THE DIFFERENT COAL FIELDS.

The following table shows how rapidly the use of permissible explosives increased in the different coal fields in the United States during four years.

Quantity of permissible explosives sold in different coal fields in the United States, 1909–1912.

Coal fields and regions.	1909	1910	1911	1912
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
1. Pennsylvania anthracite field	894,294	1,486,100	1,917,412	2,177,172
2. Northern Appalachian region [a]	5,976,625	5,967,216	6,350,272	9,267,149
3. Southern Appalachian region	1,434,950	3,188,785	3,377,268	3,920,125
4. Eastern interior field	6,955	165,975	337,012	733,940
5. Western interior field	254,475	196,560	255,050	439,825
6. Rocky Mountain region	146,700	808,200	1,177,075	1,488,789
7. Pacific coast region	228,858	8,000	14,150	122,977
	[b] 8,942,857	11,820,836	13,428,239	18,149,977

[a] Not including Pennsylvania anthracite field.

[b] Includes 344,830 pounds of short-flame explosives, the permissibility of which had not been determined.

The quantity of permissible explosives used in coal mining during the past few years no doubt replaced twice that weight of more dangerous explosives.

At many mines shot firers are employed when permissible explosives are used, and thus a more intelligent use of the explosives is insured. Furthermore, a shot firer uses less explosive for bringing down coal than a miner who loads and fires his own shots.

Although the amount of permissible explosives used in this country is larger than in some foreign countries, it still represents only a small percentage of the total amount of explosives used in coal mining. Mines that are considered gaseous generally use permissible explosives. In some fields, if a certain part of a mine, such as the advance workings, is generating gas, or if inflammable coal dust is present in quantities considered dangerous, permissible explosives are used there, and black blasting powder or dynamite is used in all other parts of the mine.

The introduction of permissible explosives and their successful application to coal mining have had gratifying results. Few, if any, accidents can be directly attributed to the use of permissible explosives, in spite of the fact that no explosive can be considered entirely safe under all mining conditions. It has been shown that when permissible explosives are used in greater quantities than recommended by the bureau, or when they are not used in accordance with the other requirements, there is a possibility of a resultant fire-damp or coal-dust explosion. Moreover, if permissible explosives, when introduced at a coal mine, are placed in the hands of miners who are unfamiliar with their use, the results obtained are liable to be unsatisfactory until the miners have learned to use the explosives to best advantage.

FATALITIES IN COAL MINES.

The death rate in the coal mines of the United States had shown an increasing tendency up to the year 1908. In the spring of 1909 the bureau issued its first list of permissible explosives, and it is gratifying to note that the increase in the use of permissible explosives during the past four years is coincident with a decrease of fatal accidents in the coal mines. The following table shows the quantity of permissible explosives sold and the number of men killed in the coal mines of the United States from 1909 to 1912, inclusive:

Quantity of permissible explosives sold and number of men killed in coal mines, 1909–1912.

Year.	Quantity of permissible explosives sold.	Number of men killed.[a]	
		Per 1,000 employed.	Per 1,000,000 short tons mined.
	Pounds.		
1909	[b] 8,942,857	4.00	5.79
1910	11,820,836	3.92	5.66
1911	13,428,239	3.73	5.48
1912	18,149,977	3.15	4.29

[a] Horton, F. W., Coal-mine accidents in the United States, 1896–1912, with monthly statistics for 1912: Technical Paper 48, Bureau of Mines, 1912, p. 8.

[b] Includes 344,830 pounds of other short-flame explosives.

The greater interest in mine safety and the better enforcement of laws and regulations by State mine inspectors have been responsible to a large extent for the reduction in the death rate in the coal mines of this country, but it is believed that the use of permissible explosives has been the important factor in lessening the death rate from gas and coal-dust explosions.

The use of unsafe explosives in coal mining, as well as the improper use of such explosives, is responsible for many of the fatal accidents accredited to mine fires, falls of roof and coal, and other causes. It is known that when black blasting powder was used mine fires were a common occurrence in certain mines working a high-volatile coal, but when black blasting powder was replaced by permissible explosives mine fires resulting from shots were eliminated. Permissible explosives when properly used do not damage the roof such as is the case when black blasting powder is used; consequently, accidents due to falls of roof are lessened by the use of permissible explosives. The actual fall of rock or coal may not occur at the time of firing the charge, but heavy charges of black blasting powder weaken the walls and roof and start cracks that impair the supports of the roof, and considerable time may elapse after a blast before the roof falls. Another advantage in the use of permissible explosives is that the miner can set the props supporting the roof closer to the face of the workings than when black blasting powder is used, and thus insure better protection against roof falls.

APPARATUS AND METHODS FOR PHYSICAL TESTS OF EXPLOSIVES.

The apparatus used and the methods of testing explosives at the Pittsburgh experiment station of the Bureau of Mines have been described in Bulletin 15, Investigations of Explosives Used in Coal Mines. The new test requirements for permissible explosives as adopted by the bureau and certain new apparatus recently devised are described in detail in this bulletin.

The tests made at the Pittsburgh experiment station may be briefly summarized as follows:

PHYSICAL EXAMINATION.

This includes the determination of the average diameter, length, and weight of the cartridge, whether or not the cartridge has been redipped, the apparent specific gravity of the cartridge as determined by sand, and the color and consistency of the explosive.

BALLISTIC PENDULUM.

This apparatus consists of two essential parts, a cannon in which the charge is fired and a pendulum which receives the impact of the products of combustion and of the stemming. The pendulum is a

12.2-inch United States mortar, weighing 31,600 pounds, which is suspended by means of a stirrup from two cast-steel saddles fitting over a steel supporting beam that rests on nickel-steel knife edges on steel bearing-plates supported by concrete piers. The swing of the mortar when the cannon is discharged into it is measured by an automatic recording device and is taken as a measure of the propulsive effect of the explosive.

GAS AND DUST GALLERY.

This gallery consists of a steel cylinder 100 feet long and 6⅓ feet in diameter, into one end of which a cannon, such as is used in the ballistic pendulum tests, is discharged. The gallery may be filled with mixtures of gas and air, coal dust and air, or of gas, coal dust, and air, and the liability of the explosive fired in the cannon igniting such mixtures is determined by test.

RATE OF DETONATION APPARATUS.

The rate of detonation of an explosive is determined by inserting cartridges of the explosive in a tube of thin sheet iron that is suspended within a firing chamber. Into one end of the file of cartridge in the tube a detonator is inserted, and through points in the file a predetermined distance apart are led the wires of an electric circuit. By means of an extremely accurate recording device (Mettegang's recorder) the time required for the passage of the explosion wave through the distance between the two electric wires can be determined to within 1/4,300,000 second.

FLAME-TEST APPARATUS.

This apparatus is used to record by photography the relative lengths and durations of the flames produced by explosives, the test being based on the belief that the longer the flame and the longer the time it endures, the greater is the chance that such a flame, when shot into the air of a coal mine, will ignite inflammable mixtures of gas and air, coal dust and air, or gas, coal dust, and air. That the volume, density, conductivity, specific capacity, and temperature of the flame are, like the length and duration, important factors in determining its effect is recognized, but these must be ascertained and their effects measured by other means. Hence too great emphasis must not be placed on the value of the length and duration of the flame of explosives as an indication of their permissibility, for both the length and the duration of the flames of certain nonpermissible explosives are less than those of some of the permissible explosives, but the other variables, particularly the temperature of the flame, are of importance and must be taken into account. Furthermore, the particular manner in which the air offers resistance to the flame may so laminate and disperse the flame that, in conjunction with other causes, its height and duration may be materially reduced. This air resistance accounts for certain variations in tests of the same explosive.

The flame-test apparatus consists essentially of a cannon, which is similar in all respects to those used in the ballistic pendulum and the gas and dust gallery tests, and a camera with suitable accessories for cutting off from a rapidly moving sensitive film all light rays except those emitted by the flame of the explosive. The length of flame is measured in milliseconds, or thousandths of a second, and the smallest time interval measurable by the apparatus is 0.0125 milliseconds.

EXPLOSION-BY-INFLUENCE TESTS.

The explosion-by-influence test determines the sensibility of an explosive to the explosion wave produced by the detonation of a mass of the same explosive. In this test two cartridges of the same explosive are placed a predetermined distance apart. One cartridge is fired by means of an electric detonator. If the second cartridge is detonated by the detonation of the first cartridge, the test is repeated with the second cartridge farther away. If the second cartridge is not detonated the test is repeated with the second cartridge nearer the first. By proceeding in this way, the minimum distance between cartridges at which the first cartridge does not detonate the second is established within 1 inch.

IMPACT MACHINE.

The impact machine is used to determine quantitatively the sensitiveness of explosives to explosion when they are struck by a known mass of steel of known velocity, while the explosive being tested rests on a steel surface. The essential parts of the apparatus are a case-hardened steel anvil that can be kept at a definite temperature by means of a water jacket, and a framework of steel rods, by means of which a steel hammer weighing 2,000 grams can be dropped from a precisely determined height on a charge of explosive on the anvil.

BICHEL PRESSURE GAGE.

The Bichel pressure gage is employed to determine the theoretical maximum pressure that an explosive would exert if exploded or detonated in a space that it fills completely, all the heat set free by the chemical reactions taking place being retained by the products of explosion. The apparatus also affords a means for collecting the resulting gaseous, liquid, and solid products. The essential features of the apparatus are two stout, steel cylinders in which the explosive is fired, and instruments by which the pressure within the cylinder is recorded. From the pressure record the rate of dissipation of the heat from the explosion is ascertained.

CALORIMETER.

The calorimeter is designed to measure the quantity of heat set free by the explosion or detonation of a known quantity of explosive. It consists of a steel bomb in which the explosion takes place; a vessel for holding a known quantity of water in which the steel bomb is immersed; a wooden cylinder which supports the vessel and also insulates it; a stirring device by which the water in the immersion vessel is stirred so that the heat evolved by the explosion is uniformly distributed throughout the water; an extremely accurate thermometer for measuring the rise of temperature of the water following the explosion of the charge within the bomb, and scales for weighing the parts of the apparatus and the water used.

SMALL LEAD BLOCK TEST.

The small lead block test is intended to determine the compressive effect exerted by a detonating explosive when exploded unconfined on the upper end of a smaller cylinder of lead. In making the test, a small steel disk is placed on the cylinder to receive the immediate impact of the detonation. The deformation of the cylinder is taken as a measure of the disruptive effect of the explosive.

TRAUZL LEAD BLOCKS.

The Trauzl lead block test is designed to measure the comparative disruptive effect of explosives fired under moderate confinement. Equal weights of different explosives are confined in bore holes of definite dimensions made in lead blocks of prescribed character by means of a fixed quantity of stemming, and, when thus confined, are exploded by means of similar detonators. The measure of the test is the volume by which the cavity in the block is enlarged by pressure exerted by the explosive.

Apparatus other than the gallery used for testing the relative safety of coal-mining explosives and the methods of testing under accurately controlled conditions do not simulate actual conditions of practice, but it is generally recognized that such empirical tests have resulted in the use of safer explosives in coal mines.

PHYSICAL EXAMINATION.

In the physical examination of explosives the classification with respect to consistence has been elaborated in order to cover the characteristics of some of the recent explosives submitted for official tests. All explosives are now classified with regard to the following characteristics:

- Consistence:
  - Granulation:
    - Structure:
      - Granular.
      - Fibrous.
      - Powdered.
      - Gelatinous.
    - Size:
      - Very fine.
      - Fine.
      - Coarse.
      - Very coarse.
  - Liquidness:
    - Very wet.
    - Wet.
    - Dry.
    - Very dry.
  - Compactness:
    - Very hard.
    - Hard.
    - Soft.
    - Very soft.
  - Cohesiveness:
    - Very cohesive.
    - Moderately cohesive.
    - Slightly cohesive.
    - Not cohesive.

BICHEL PRESSURE GAGES.

The construction of the pressure gages has not been altered since they were received at the experiment station, but the method of conducting tests has been slightly modified. Formerly, as in the tests described in Bulletin 15, the explosive was removed from its original wrapper and then wrapped in an envelope of tin foil before being placed in the gage. Gage tests of all explosives reported in this bulletin were made by firing charges of explosives in their original wrappers. It has been found that the paper wrapper of explosives, which represents a comparatively large percentage by weight of the combustible material, is an important factor in the character of the gaseous products evolved when the explosives are burned or detonated. The following are the analyses of the gases produced by firing in the gage equal charges of the same explosive with and without paper wrappers:

Gaseous products evolved on detonation of an explosive in Bichel pressure gage.

[Analyst, A. L. Hyde.]

Gaseous products.	With paper wrapper.	Without paper wrapper.
	Per cent.	*Per cent.*
Carbon dioxide	27.3	51.4
Carbon monoxide	26.9	5.0
Oxygen	.0	.0
Hydrogen	18.0	2.2
Methane	.4	.3
Nitrogen	27.4	41.1

The analyses show that when the explosive was fired in its original wrapper there was an increase in the percentage of carbon monoxide formed. Other tests made with different kinds of explosives confirmed these results.

GASEOUS PRODUCTS EVOLVED ON DETONATION OF EXPLOSIVES IN FIELD TESTS.

The results of tests made in the field indicate that the gaseous products evolved on the detonation of all coal-mining explosives, together with the gases produced by the coal itself, are extremely poisonous and inflammable. The analyses of mine-air samples collected after shots in coal mines show that more carbon monoxide is formed when explosives are fired under actual working conditions than when fired in the gage. Some of the fine coal left in the drill hole is ignited and causes the increased amount of carbon monoxide formed.

It has been generally conceded that the permissible explosives that are deficient in oxygen and have passed all test requirements in metal cannons would produce a lower temperature when fired in a drill hole in coal, for the reason that any further addition of carbon would result in an increase of carbon monoxide, which would cause a reduction of the flame temperature. But the question has been raised whether the permissible explosives having an excess of oxygen would produce a higher temperature when fired in coal because of the possibility of the excess of oxygen uniting with just enough of the coal to form carbon dioxide. The results of the investigation of one explosive having an oxygen excess have not borne out this contention. On the other hand, all indications point to the fact that explosives of this kind are equally safe when fired in coal. Analyses of the gases produced from an explosive having an oxygen excess when fired in the gage and also the gaseous products of the same explosive when fired under actual working conditions are given in the following table:

Gaseous products evolved on detonation of an explosive in Bichel pressure gage and in field tests.

[Analyst, A. L. Hyde.]

Gaseous products.	Gage test.		Field test.[a]
	With paper wrapper.	Without paper wrapper.	With paper wrapper.
	Per cent.	*Per cent.*	*Per cent.*
Carbon dioxide	30.0	24.3	22.6
Carbon monoxide	.0	.0	11.4
Oxygen	2.2	8.8	.0
Hydrogen	.0	.0	6.8
Methane	.7	.4	.7
Nitrogen	67.1	66.5	58.5

[a] Computed on an air-free basis; the methane produced from the coal was subtracted to make the methane percentage correspond to that in the gases from samples tested in the gage.

The analysis of the gases produced in field test shows a decrease in carbon dioxide and the production of a considerable amount of carbon monoxide. The field samples also show the presence of 6.8 per cent of hydrogen. On the assumption that this hydrogen was produced at the expense of some of the water in the products of combustion, the formation of less water and more hydrogen necessarily being accompanied by a smaller evolution of heat, its presence is further evidence of the reduction of flame temperature under actual working conditions. This reduction of temperature would offset any increase in the length of duration of the flame caused by the coal entering into the explosive reaction.

NEW REQUIREMENT WITH RESPECT TO THE KIND AND QUANTITY OF GASES EVOLVED ON DETONATION OF PERMISSIBLE EXPLOSIVES.

A list of permissible explosives issued by the bureau January 1, 1911, contained the names of a few explosives that on detonation in the Bichel gage developed large quantities of carbon monoxide. In tests of these explosives in coal mines it was found that when the usual charge was fired in rooms no appreciable amount of carbon monoxide was detected in samples of the mine air taken at the face immediately after the shot. However, when tests were made in narrow entries in coal mines, ahead of the air, all mine-air samples taken immediately after firing charges of 680 grams (1½ pounds) showed the presence of carbon monoxide, and one sample contained as much as 0.11 per cent of the gas.

Other permissible explosives that on detonation in the gage evolved less carbon monoxide were tested in coal mines. These explosives did not appreciably vitiate the mine air in rooms or in narrow entries even when there was no circulation of air near the face. The highest percentage of carbon monoxide found in any of these mine-air samples taken immediately after the shot was 0.02.

It has been found, too, that all explosives which on detonation evolve 158 liters (5½ cubic feet) or more of permanent poisonous gases from a 680-gram (1½-pound) charge as determined by gage tests, when used in 680-gram (1½-pound) quantities in narrow entries in coal mines, ahead of the air, may for several minutes after a shot so vitiate the air near a face as to make it harmful. Of course, the conditions mentioned are unfavorable to any explosive and are abnormal in that there is no circulation of air near the face. However, as such conditions actually exist in some coal mines, all explosives that produce 5½ cubic feet (158 liters) or more of poisonous gases from a 1½-pound charge have been eliminated from the permissible list.

BALLISTIC PENDULUM.

Observations and tests in the field have shown that the ballistic pendulum and pressure gages measure the propulsive effect which approximately corresponds to the heaving or pushing force of explosives more nearly than any of the other apparatus used in testing explosives at the Pittsburgh experiment station. The tests with small lead block, the Trauzl lead block, and the rate-of-detonation apparatus measure approximately the disruptive (shattering) effect of explosives. It has been impossible to devise a single piece of apparatus for measuring both the propulsive and disruptive effects of explosives, and it is questionable if the combined effects determined by a single apparatus and expressed as the total energy of an explosive would be of any practical value. The useful work explosives can do depends on the material to be blasted and the method of application, etc. On account of varying conditions, certain characteristics of an explosive may be of more importance in some kinds of blasting than in others. Evidently if each of the fundamental characteristics of explosives was expressed in comparative figures the information would be a useful guide in selecting an explosive for a particular work. For this reason comparative figures are given for all tests of explosives reported in this bulletin.

NEW REQUIREMENTS WITH RESPECT TO THE EFFICIENCY OF PERMISSIBLE EXPLOSIVES.

During the past two years several permissible explosives have been withdrawn from the market by their manufacturers. All explosives that are no longer being manufactured, as well as those that have shown unfavorable results in field tests, have been eliminated from the list.

In the ballistic-pendulum test for determining the propulsive effect of an explosive the standard deflection of the pendulum is that produced by one-half pound (227 grams) of 40 per cent nitroglycerin dynamite. Some explosives do not produce an equal deflection unless they are used in charges of 1 pound (454 grams) or more, and it has been found that these explosives must be used in charges of more than 1½ pounds in order to satisfactorily break down coal. It is believed that in gaseous or dusty coal mines no explosive can be used safely in quantities greater than 1½ pounds per shot. Consequently all explosives that under normal conditions of mining can not be satisfactorily used in charges of 1½ pounds or less have been eliminated from the permissible list.

CALORIMETER.

In tests to determine the quantity of heat set free all explosives are now fired in their original wrappers. By determining the quantity of heat evolved in the calorimeter, the potential energy of explosives can be computed. The potential energy thus obtained represents the maximum work an explosive can theoretically accomplish, but as the useful work resulting from the use of explosives is a small percentage of the maximum, and varies considerably with the different classes of explosives, knowledge of the potential energy of explosives is of little value in selecting a suitable explosive.

Knowledge of the quantity of heat evolved on explosion is useful in determining the temperature of explosion, but too great an emphasis must not be placed on flame temperature alone as a measure of the permissibility of an explosive for use in coal mines. One explosive may develop a lower temperature on explosion than another, yet the duration of the flame may be such as to render the explosive of lower flame temperature unsuitable for use in coal mines.

A drill hole in coal or rock when filled with a charge of explosive is practically free of air; therefore these conditions must necessarily be simulated in experimental tests. In the calorimeter the air is almost entirely removed when explosives are tested. Explosives sometimes detonate incompletely and evolve oxides of nitrogen. It is generally recognized that a vacuum prevents the explosion of powder, and that high explosives are more likely to detonate incompletely when fired in a vacuum, especially when the charging density is low. It was therefore sometimes necessary to make several calorimeter tests in order to obtain satisfactory results. An incomplete detonation or the evolution of oxides of nitrogen in a calorimeter test should not be interpreted as an unfavorable result, for the reason that in practice explosives are never fired in a vacuum.

GAS AND DUST GALLERY NO. 1.

The position of the cannon in the gas and dust gallery No. 1 has been changed (see Pl. I, *A*). Formerly the cannon was embedded in the concrete head of the gallery and the replacement of worn-out cannons was difficult and expensive. That end of the gallery which was embedded in a concrete head is now closed by a steel head having in the center a hole 12 inches in diameter. The cannon is mounted on a 4-wheel truck which runs on a 30-inch (76.2-centimeter) gage track, and is placed so that the axis of its bore hole coincides with the longitudinal axis of the gallery. After the cannon is loaded it is rolled against the steel head and a close fit is made by means of a rubber gasket. A concrete arch surrounds the cannon to prevent pieces of metal from flying in the event of the cannon bursting. Behind the truck and 19 feet from the head of the gallery is a concrete barricade. The mouth of the cannon is in the same relative position as when the cannon was embedded in the concrete head. The change made does not affect the tests, while, on the other hand, a worn-out cannon can be easily replaced. It has been found that all explosives which pass official tests 1, 3, and 4 always pass tests 2 and 5. In view of this fact tests 2 and 5 have been discontinued as they were not considered discriminative.

CONSTRUCTION OF CANNON.

The principal expense involved in testing explosives is the cost of the cannon used. Various materials and methods of construction have been tried in an endeavor to obtain cannon which would best resist the shattering effects of the explosive. Black blasting powder and other slow-burning explosives have little effect on a cannon, but detonating explosives invariably disrupt it after a certain number of shots. Six thousand four hundred and eighty-six shots were fired in the first 46 cannons used at the Pittsburgh experiment station, or an average of 141 shots per cannon. Of these cannon 12 were relined with forged steel liners varying in diameter from 5 to 6 inches, so that the average number of shots per liner was 112. With the type of cannon now used it is possible to use two and sometimes three extra liners with each cannon, thus increasing the number of shots that can be fired in each cannon and materially reducing the expense. The first cannons used at the testing station were of the built-up type, the jacket being of cast low-carbon steel and the liner of forged nickel steel. Later solid steel forgings having the same length and diameter as the built-up cannons were tried. Different requirements covering the composition and physical properties of the materials were specified in the purchase of the solid forgings. These forgings made with varying amounts of carbon and nickel were tried, and one cannon was made containing 0.20 per cent of vanadium. The solid steel forgings proved less resistant than the built-up cannons, and hence the use of such forgings was discontinued. A wire-wound cannon designed by the Ordnance Department of the United States Army and manufactured at Watervliet Arsenal burst after a few limit-charge tests. The jacket of the built-up cannons now used is a casting of soft steel thoroughly annealed. The liner is a soft low-carbon steel forging which elongates when explosives are fired within it. Hence the jacket is not subjected to the strain it would receive if elongation did not take place.

NONMETALLIC LINERS.

Several tests have been made with small nonmetallic liners in an endeavor to prevent the breaking of liners and jackets by explosions. Portland cement, plaster of Paris, and cement liners containing crushed coal were tried, but it was found that, although the life of a cannon might possibly be prolonged, the liners were pulverized, and the pulverized material projected into the gallery had a tendency to reduce the temperature of the gaseous products of explosion. Consequently, the use of such liners was not deemed desirable in determining the permissibility of explosives. In several instances nonpermissible explosives passed one or more of the gas and dust gallery tests when nonmetallic liners were used, but failed under the regular conditions of testing.

ADOBE SHOTS IN COAL MINES.

Results of tests made in the gallery indicate that no explosive is safe for "adobe shots"[a] in breaking up large pieces of rock or coal or in breaking down stoppings in coal mines where either gas or dry inflammable dust is present in quantities or under conditions that indicate danger. Black blasting powder, even when covered with large quantities of clay, can not be safely or effectively used for this work. Ordinary dynamites are equally unsafe, even when put in a bucket of water placed on the material to be broken they give sufficient flame to cause the explosion of an inflammable mixture of gas and air. Permissible explosives have been found to be safer than black blasting powder or ordinary dynamite for use in "adobe shots," but the charges used must be small and must be well covered with moist clay. However, all permissible explosives, when fired under these conditions in the presence of a mixture of gas and air containing 8 per cent of gas (methane) are likely to cause ignition and consequently "adobe shots" should never be fired in the pres-

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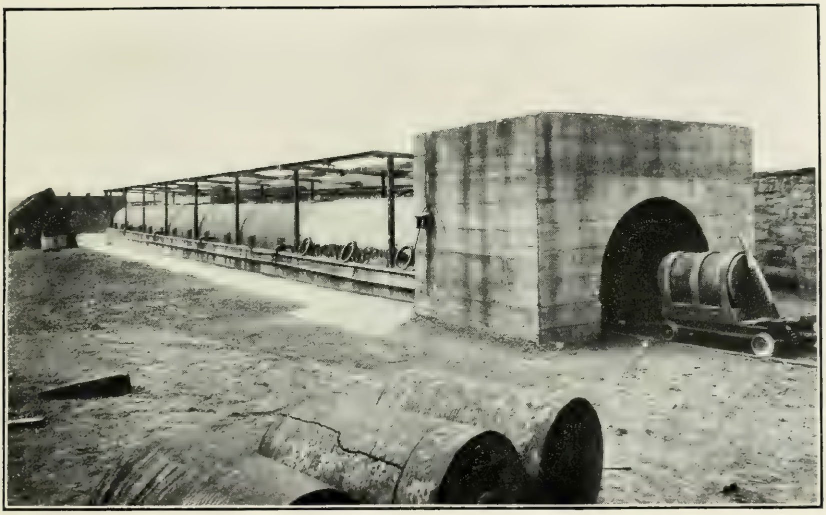
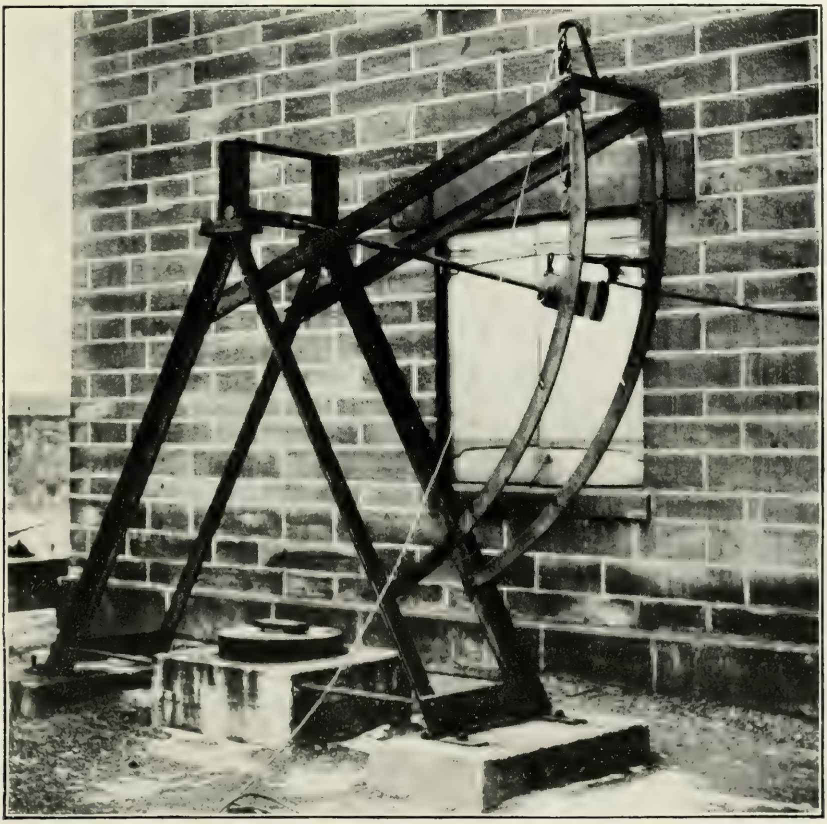
[a] For an "adobe shot" the explosive is placed on the thing to be broken. This method of using an explosive is also called "bulldozing."



A. GAS AND DUST GALLERY NO. 1.



B. PENDULUM FRICTION DEVICE.

ence of fire damp. In emergencies, such as in fighting mine fires or in recovery work when "adobe shots" are absolutely necessary, the working place should be carefully tested for gas before firing. The charge used should not exceed 1½ pounds and it should be well covered with moist clay.

MAXIMUM CHARGE PERMISSIBLE FOR USE IN COAL MINES.

The underlying reasons why one explosive passes and another fails when tested in the presence of inflammable gas and dust have been investigated at the Pittsburgh experiment station.

The results of tests indicate that any explosive fired in large quantities will cause ignition of inflammable gas and coal dust mixtures. An arbitrary charge, namely, 1½ pounds, has been established as the maximum amount of explosive to be used in making tests, and all explosives in order to be placed on the permissible list must pass the gas and dust test with this charge. A charge of 1½ pounds of explosive per drill hole should never be exceeded in practice; in good mining practice the charge need not exceed 1 pound, an amount which gives a greater factor of safety.

Explosives of many different compositions are now on the permissible list, but every one is designed to give on detonation a relatively low flame temperature and a flame of short duration. To ignite inflammable gas and coal dust mixtures a certain temperature, acting through a certain length of time, is required. The flame temperature of all explosives exceeds the ignition temperature of inflammable gas and dust mixtures, but fortunately the flame of a permissible explosive properly detonated is of such short duration that under the conditions of blasting down coal it does not ignite the inflammable mixtures. Manifestly, any factor that increases the duration of the flame temperature of a permissible explosive increases the danger in the use of that explosive. Such danger is present when an improper detonator is used or when any explosive is not used in accordance with the provisions prescribed by the Bureau of Mines.

NEW TESTING APPARATUS.

PENDULUM FRICTION MACHINE.

A new test, the sensitiveness of explosives to frictional impact (a glancing blow) has been adopted by the Bureau of Mines. The apparatus used (see Pl. I, *B*, and fig. 1) comprises a steel anvil and a swinging steel shoe. The anvil has a smooth face, 3¼ inches wide by 12 inches long, in the middle of which are three grooves for holding the charge of explosive. The radius of swing of the shoe is 6 feet 6¾ inches and the radius of curvature of its face is 10½ inches. The shoe can be faced with hardwood fiber or other material, and may be dropped from heights of 19.7 to 78.7 inches (½ to 2 meters). Weights of 2.2

to 44 pounds (1 to 20 kg.) are used in the tests. Details of the machine are shown in figure 1.

The test was devised to represent what may happen in mining when a cartridge of explosive becomes lodged in a drill hole and must be forced home by ramming. Some explosives have been found to be extremely sensitive to the frictional-impact test even when the shoe is faced with wood fiber. Consequently great care should be exercised with all explosives in charging drill holes.

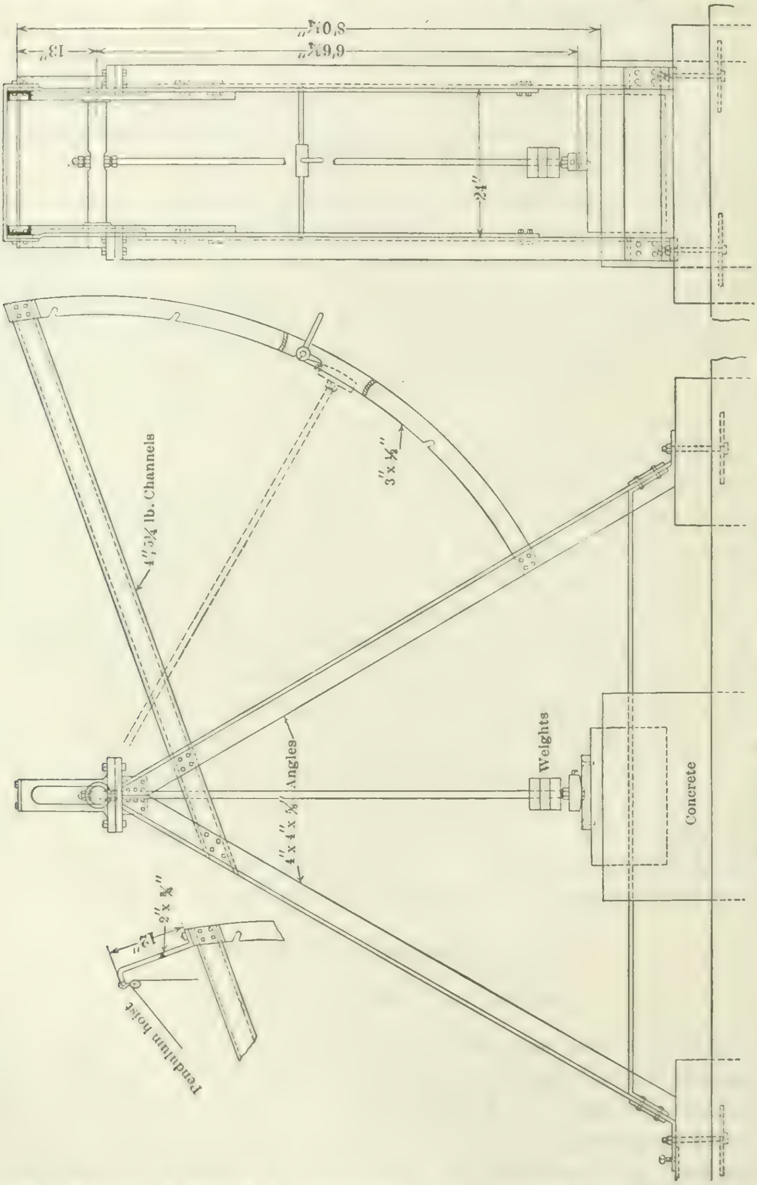


FIGURE 1.—Elevation and details of pendulum friction machine.

LARGE IMPACT MACHINE.

A new and much larger impact machine (fig. 2) constructed somewhat on the same principle as the small impact machine already mentioned was recently installed at the Pittsburgh testing station. Like the small machine it is designed to determine the sensitiveness of explosives to explosion by direct impact. The falling weight used in the test is 200 kilograms (441 pounds); the maximum height from which the hammer can be dropped is 7.5 meters (24.6 feet); the charge of explosive used, 20 grams (309 grains), is placed on the anvil in the form of a flat disk 10 centimeters (3.94 inches) in diameter. The face of the anvil and the face of the plunger are 12.7 centimeters (5 inches) in diameter. Tests are conducted in the same way as with the small impact machine. The advantage of the large machine is that it permits the use of larger charges of explosives, thus minimizing the variables, such as the physical constitution of the explosive, that affect the results obtained with the small machine; the charge being larger more nearly represents the explosive, and the irregularities with respect to the composition and size of the ingredients of an explosive are minimized. Another advantage is that in the tests there is usually a sharp report or no explosion, whereas with an impact machine using a small quantity of explosive it is difficult sometimes to determine whether an explosive detonates completely or partly, or merely ignites. The greatest advantage of the large machine is that tests can be made with explosives when confined between two disks, 9.8 cm. in diameter, fitted into a piece of Shelby steel tubing the height of which is equal to the total thickness of the two disks. From comparative tests with large and small machines it is believed that the results obtained with the large impact machine when the explosives are confined more nearly represent the relative sensitiveness of explosives to direct impact.

CLASSES OF PERMISSIBLE EXPLOSIVES.

In order that the users of explosives may know the nature and characteristic component of each of the permissible explosives, and as an aid in the selection of an explosive to meet a specific requirement, the permissible explosives have been arranged in four classes. In classifying the permissible explosives, both the composition of the explosive and the behavior of the characteristic component material when stored or used were considered.

The four classes and the general characteristics of the permissible explosives are as follows:

Class 1, ammonium nitrate explosives.—To class 1 belong all the explosives in which the characteristic material is ammonium nitrate.

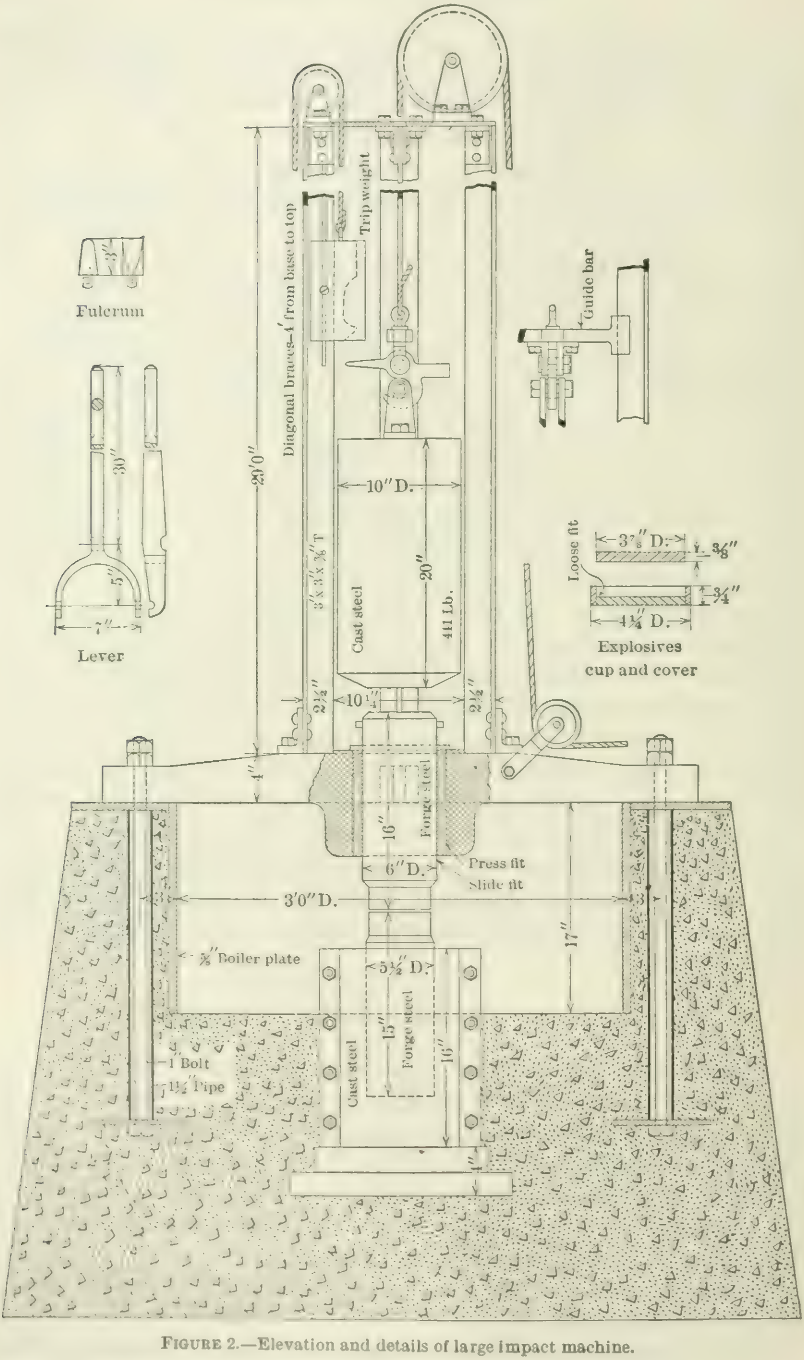


FIGURE 2.—Elevation and details of large impact machine.

The class is divided into two subclasses. Subclass *a* includes every ammonium nitrate explosive that contains a sensitizer that is itself an explosive. Subclass *b* includes every ammonium nitrate explosive that contains a sensitizer that is not in itself an explosive. The ammonium nitrate explosives of subclass *a* consist principally of ammonium nitrate with small percentages of nitroglycerin, nitrocellulose, or nitrosubstitution compounds which are used as sensitizers. The ammonium nitrate explosives of subclass *b* consist principally of ammonium nitrate with small percentages of resinous matter or other nonexplosive substances used as sensitizers.

All of the ammonium nitrate explosives readily absorb moisture from the atmosphere, and great care should be taken in storing them or in using them in damp places. They are not suitable for use in wet mines. If in such a mine a cartridge of an ammonium nitrate explosive is opened and its contents exposed for only a few hours to the damp atmosphere the explosive may deteriorate and later fail to detonate completely. The ammonium nitrate explosives when stored in well-ventilated magazines for only a few months have shown signs of deterioration, and nearly all explosives of this class after six months' storage at the Pittsburgh experiment station have either failed to detonate or have detonated incompletely. For this reason ammonium nitrate explosives should be obtained in a fresh condition and should be used as soon as possible after their receipt. When fresh, these explosives, if properly detonated, have the advantage of producing only small quantities of poisonous and inflammable gases, and are adapted for mines that are not unusually wet, and also for mines and working places that are not well ventilated.

Class 2, hydrated explosives.—To class 2 belong all explosives in which salts containing water of crystallization are the characteristic materials. The explosives of this class are somewhat similar in composition to the ordinary low-grade dynamites, except that one or more salts containing water of crystallization are added to reduce the flame temperature. They are easily detonated, produce only small quantities of poisonous gases, and most of them can be used successfully in damp working places.

Class 3, organic nitrate explosives.—To class 3 belong all the explosives in which the characteristic material is an organic nitrate other than nitroglycerin. The permissible explosives listed under class 3 are nitrostarch explosives. They produce small quantities of poisonous gases on detonation.

Class 4, nitroglycerin explosives.—To class 4 belong all the explosives in which the characteristic material is nitroglycerin. These explosives contain free water or an excess of carbon, which is added to reduce the flame temperature. A few explosives of this class contain salts that reduce the strength and shattering effect of the explosives on detonation. Nitroglycerin explosives have the advantages of detonating easily and of not being readily affected by moisture. On detonation some of them produce as large quantities of poisonous and inflammable gases as black blasting powder, and for this reason they should not be used in mines or working places that are not well ventilated.

RATE OF DETONATION OF PERMISSIBLE EXPLOSIVES.

The energy developed by the detonation of permissible explosives, like that of other high explosives, depends on the change of the small solid and liquid particles of the explosive into large volumes of highly heated gases and on the rate of detonation or the rapidity with which these gases are formed. The force exerted by these gases is the means of producing useful effects. The rate of detonation is the governing factor in judging the efficiency of an explosive and it offers the best single means for selecting explosives suitable to meet the varying conditions of coal mining.

During the conversion of an explosive into solid, liquid, and gaseous products the cooling effect of the walls of the drill hole tends to lower the temperature of the gases so that the maximum theoretical temperature, or pressure, is never reached. The more nearly instantaneous the explosive reaction, all other conditions being equal, the greater the volume of highly heated gases produced, and the more violent the effect.

To meet the varying conditions of coal mining in this country the explosives manufacturers have devised explosives with rates of detonation that range from 4,750 to 14,560 feet (1,447 to 4,439 meters) per second.

SUGGESTIONS USEFUL IN SELECTING EXPLOSIVES.

It is hoped that with few exceptions the classification given will serve as a useful guide for comparing the practical value of permissible explosives. However, in order to select the most suitable, users of these explosives should conduct a series of experiments in the mine. The information given herein should eliminate the necessity of testing many different classes and brands of explosives.

It is evident that for certain work in which a shattering effect is desired, as in driving through or "brushing" rock, or in producing coal for coking purposes, the explosive reaction should be rapid. Hence, permissible explosives having a high rate of detonation should be selected. Similarly, for use in soft friable coal to produce lump or steam coal, selection should be made of a permissible explosive that detonates slowly and hence gives a more prolonged pressure. In medium hard coal an explosive having an intermediate rate of detonation would be expected to be most suitable, but is not always so. Coals vary in hardness and coal beds vary in the number and position of the joints, partings, shale bands, etc. These facts have to be considered in mining.

An explosive having a very low rate of detonation is not always best suited for mining soft friable coal, because some of its energy may be lost by its gases escaping through cracks and fractures in the bed. Under such conditions an explosive having an intermediate rate produces the most economical results.

Another factor to be considered in connection with an explosive having a high rate of detonation or the use of a large charge of any explosive is the possible effect on the roof, or the strata overlying the coal bed. Large charges of explosives having a very high rate of detonation cause small fissures that may later necessitate extra timbering to prevent falls in rooms or entries, and thus make the operation of a mine more costly.

It is well known that the pressure developed by the detonation of explosives in a closed space is directly proportional to the charging density; in other words, a 1¾-inch drill hole loaded with 1¼-inch cartridges will produce on the walls of the drill hole about one-half as much pressure per square inch as it would if loaded with cartridges of 1¾-inch diameter. A limited experience indicates that explosives having a rapid rate of detonation will yield a larger proportion of lump coal if used in a hole of larger diameter than the cartridge. Such air spacing to reduce the shattering effect of an explosive is recommended by the Bureau of Mines, provided the charge is confined with moist clay stemming tamped to the mouth of the drill hole.

Other less desirable means of reducing the shattering effect of an explosive are the use of an improper detonator, reducing the amount of stemming, using an explosive that is frozen or partly frozen, using an explosive in cartridges of less diameter than those originally tested, and introducing foreign substances between the cartridges of an explosive; but these methods are all dangerous. They not only eliminate the safety qualities of the explosive but increase the chance of a resultant dust or gas explosion, and should not be adopted.

RESULTS OF TESTS WITH DETONATORS AND ELECTRIC DETONATORS.

Permissible explosives are detonated by means of detonators or electric detonators, which are graded by number according to the weight of fulminating charge. Different types of explosives require detonators of different strength. Detonators are usually fired with fuse. A detonator fitted with a means of firing it with an electric current is called an electric detonator. As an electric detonator is embedded in the explosives with which it is used and is isolated by the stemming, it is the safest means of igniting a charge of explosive in a gaseous mine.

One of the conditions prescribed by the Bureau of Mines for a permissible explosive is that it shall be fired by a detonator, preferably an electric detonator having a charge equivalent to that of the standard detonator used at the Pittsburgh experiment station. It is further required that this charge shall consist by weight of 90 parts of mercury fulminate and 10 parts of potassium chlorate (or their equivalents).

An investigation undertaken by the Bureau of Mines shows that the average percentage of failures of explosives to detonate is increased over 20 per cent when the lower grades of electric detonators were used instead of No. 6 electric detonators, and over 50 per cent when compared with No. 8 electric detonators.[a] However, when sensitive explosives were tested under the conditions most favorable to detonation, the same energy was developed irrespective of the detonator used. When tests were made with insensitive explosives under conditions which similate their use in blasting, the energy increased with the grade of the detonator used. For example, the average explosive efficiency of four different explosives was increased 10.4 per cent by using a No. 6 electric detonator instead of a No. 4 electric detonator, and 14.9 per cent by using a No. 8 electric detonator. The tests emphasize the importance of using explosives in a fresh condition, and, since this is not always possible, the importance of strong detonators in blasting to offset any deterioration of the explosive through ageing.

The results substantiate these conclusions: (1) That the explosive efficiency of the detonators made by any one manufacturer increases with the grade; (2) that No. 6 electric detonators of four different makes have practically the same explosive efficiency; and (3) each is considered equivalent to the Pittsburgh experiment station standard No. 6 electric detonator for use with permissible explosives in coal mines when the No. 6 grade is prescribed.

RESULTS OF TESTS OF PERMISSIBLE EXPLOSIVES.

ÆTNA COAL POWDER AA.

Explosive, Ætna coal powder AA.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Ætna Powder Co.
Physical examination:
  Diameter of cartridge, 1½ inches.
  Length of cartridge, 8 inches.
  Average weight, 261 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.04.
  Color of explosive, drab.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

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[a] Hall, Clarence, and Howell, S. P., Investigations of detonators and electric detonators: Bull. 59, Bureau of Mines, 1913, p. 73.

Unit deflective charge as determined by the ballistic pendulum:

Date, September 28, 1909.
Unit swing on this date, 2.65 inches.
Weight of charge, in grams, 230, 230, 230.
Swing, in inches, 2.50, 2.63, 2.46.
Average swing, in inches, 2.53.

2.53 : 2.65 : : 230 : (241).

Therefore the unit deflective charge of Ætna coal powder AA is 241 grams.

Gas and Dust Gallery No. 1.

Date (1909).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Sept. 29	241	7.81	No ignition.
Do	241	8.11	Do.
Do	241	7.81	Do.
Do	241	7.81	Do.
Sept. 30	241	8.05	Do.
Do	241	8.05	Do.
Do	241	8.05	Do.
Do	241	7.87	Do.
Do	241	7.79	Do.
Do	241	7.87	Do.
TEST 3.			
Sept. 30	241	....	No ignition.
Do	241	....	Do.
Do	241	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Sept. 30	241	....	No ignition.
Do	241	....	Do.
Do	241	....	Do.
Do	241	....	Do.
Do	241	....	Do.
Do	241	....	Do.
Do	241	....	Do.
TEST 4.			
Sept. 27	[a] 680	4.44	No ignition.
Do	[a] 680	4.19	Do.
Do	[a] 680	4.20	Do.
Do	[a] 680	4.19	Do.
Do	[a] 680	4.19	Do.

[a] 680 grams or more was used.

Rate of Detonation.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1909).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Sept. 28	18.09	43.0	2,377
Sept. 29	17.55	43.0	2,450
Do	18.05	43.0	2,382

Average rate of detonation, 2,403 meters (7,880 feet) per second.

Flame Test.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 11	13.50	17.05	6.50	0.325
Do	13.00	16.42	7.50	.375
Do	12.00	15.16	5.00	.250

Average height of flame, 16.21 inches.
Average duration of flame, 0.317 millisecond.

IMPACT TEST.

Date, January 5, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	10	1	No explosion.
18	1	Do.	11	3	Do.
16	1	Do.	11	1	Explosion.
12	1	Do.	10	4	No explosion.

The maximum height at which no explosion occurs established at 10 centimeters (3.94 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 166 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Dec. 14	6	Did not explode.	Dec. 14	4	Exploded.
Do	4	Do.	Dec. 16	5	Did not explode.
Do	2	Exploded.	Do	5	Do.
Do	3	Do.	Do	5	Do.
Do	4	Did not explode.			

The minimum distance at which no explosion occurs established at 5 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912–13).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Dec. 30	212	1.02	30.00	93.75	A	93.75
Jan. 2	212	1.02	30.50	95.31	A	
Do	212	1.02	29.50	92.19	A	
Dec. 28	212	1.02	29.00	90.62	B	93.23
Dec. 30	212	1.02	30.25	94.53	B	
Do	212	1.02	30.25	94.53	B	
Dec. 27	212	1.02	27.75	86.72	C	88.02
Do	212	1.02	28.00	87.50	C	
Dec. 28	212	1.02	28.75	89.84	C	

[a] Including 12 grams original wrapper.

$P=1.911A+0.5B-1.411C=101.58$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.02$. $W=212$ grams.

$M=\frac{VPS}{W}=7{,}331$ kilograms per square centimeter (104,270 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 12 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, December 10, 1912.

	Grams.
Solid	27.7
Liquid (water)	61.5
Gaseous	111.6

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°C	*Calories.*
Jan. 9	81.95	1.111	971.9
Do	81.95	1.106	967.5
Do	81.95	1.059	926.0

[a] Including 6 grams of original wrapper.

Average large calories per kilogram of explosive, 955.1.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters*
Mar. 10	63.50	56.00	7.50
Do	63.00	55.50	7.50
Do	63.50	55.25	8.25

Average compression, 7.8 millimeters (0.31 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°C.
May 26	63	229	166	15
Do	63	236	173	15
Do	63	230	167	15

Average expansion of bore hole, 169 cubic centimeters (10.31 cubic inches).

ÆTNA COAL POWDER C.

Explosive, Ætna coal powder C.
Class 4, nitroglycerin.
Manufactured by the Ætna Powder Co.
Physical examination:
  Diameter of cartridge, 1½ inches.
  Length of cartridge, 8 inches.
  Average weight, 316 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.22.
  Color of explosive, drab.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, September 28, 1909.
Unit swing on this date, 2.65 inches.
Weight of charge, in grams, 340, 340, 340.
Swing, in inches, 2.64, 2.63, 2.59.
Average swing, in inches, 2.62.

2.62 : 2.65 : : 340 : (344).

Therefore the unit deflective charge of Ætna coal powder C is 344 grams.

GAS AND DUST GALLERY No. 1.

Date (1909).	Weight of charge.	Methane and ethane.	Result.	Date (1909).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Sept. 29	344	8.55	No ignition.	Oct. 1	344	....	No ignition.
Do	344	8.55	Do.	Do	344	....	Do.
Do	344	8.38	Do.	Do	344	....	Do.
Do	344	8.38	Do.	Do	344	....	Do.
Do	344	8.05	Do.	Do	344	....	Do.
Do	344	8.05	Do.	Do	344	....	Do.
Do	344	7.88	Do.	Do	344	....	Do.
Do	344	7.96	Do.				
Do	344	7.78	Do.	TEST 4.			
Do	344	8.05	Do.				
				Sept. 27	[a]680	4.44	No ignition.
TEST 3.				Do	[a]680	4.39	Do.
				Do	[a]680	4.52	Do.
Sept. 30	344	....	No ignition.	Do	[a]680	4.46	Do.
Oct. 1	344	....	Do.	Do	[a]680	4.35	Do.
Do	344	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1909).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Sept. 28	20.72	43.0	2,075
Sept. 30	19.36	43.0	2,221
Oct. 1	20.30	43.0	2,118

Average rate of detonation, 2,138 meters (7,010 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 29	17.50	22.11	9.00	0.450
Do	15.75	19.89	7.50	.375
Do	15.25	19.26	7.50	.375

Average height of flame, 20.42 inches.
Average duration of flame, 0.400 millisecond.

IMPACT TEST.

Date, May 6, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
12	1	Explosion.	8	1	Explosion.
10	1	Do.	7	2	No explosion.
8	1	No explosion.	7	1	Explosion.
9	2	Do.	6	5	No explosion.
9	1	Explosion.			

The maximum height at which no explosion occurs established at 6 centimeters (2.36 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 172 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Dec. 18	6	Did not explode.	Dec. 18	5	Did not explode.
Do	4	Do.	Do	5	Exploded.
Do	3	Exploded.	Do	6	Did not explode.
Do	4	Do.	Do	6	Do.
Do	5	Did not explode.			

The minimum distance at which no explosion occurs established at 6 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912–13).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Jan. 2	215	1.08	16.25	50.78	A	51.56
Do	215	1.08	16.25	50.78	A	
Jan. 3	215	1.08	17.00	53.12	A	
Dec. 26	215	1.08	15.50	48.44	B	48.18
Do	215	1.08	15.25	47.66	B	
Do	215	1.08	15.50	48.44	B	
Dec. 27	215	1.08	15.25	47.66	C	47.14
Do	215	1.08	15.00	46.88	C	
Do	215	1.08	15.00	46.88	C	

[a] Including 15 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=56.11$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.08$. $W=215$ grams.

$M=\frac{VPS}{W}=4{,}228$ kilograms per square centimeter (60,140 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 15 GRAMS OF ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, December 11, 1912.	Grams.
Solid	81.7
Liquid (water)	11.8
Gaseous	102.6

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 10	63.50	52.50	11.00
Do	63.50	53.00	10.50
Do	63.50	53.00	10.50

Average compression, 10.7 millimeters (0.42 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
May 26	63	207	144	15
Do	63	208	145	15
Do	63	207	144	15

Average expansion of bore hole, 144 cubic centimeters (8.78 cubic inches).

BENTAL COAL POWDER NO. 1-A.

Explosive, Bental coal powder No. 1-A.

Class 1*a*, ammonium nitrate, containing nitroglycerin.

Manufactured by the Independent Powder Co.

Physical examination:

Diameter of cartridge, 1¼ inches.

Length of cartridge, 7⅞ inches.

Average weight, 179 grams.

Cartridge had been redipped.

Apparent specific gravity of cartridge by sand, 1.09.

Color of explosive, gray.

Consistency, powdered, very fine, very dry, very soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, December 4, 1911.

Unit swing on this date, 3.40 inches.

Weight of charge, in grams, 280, 280, 280.

Swing, in inches, 3.41, 3.40, 3.44.

Average swing, in inches, 3.42.

3.42 : 3.40 : : 280 : (278).

Therefore the unit deflective charge of Bental coal powder No. 1-A is 278 grams.

GAS AND DUST GALLERY No. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Dec. 6	278	7.83	No ignition.
Do	278	7.91	Do.
Do	278	8.21	Do.
Do	278	7.91	Do.
Do	278	8.22	Do.
Do	278	8.31	Do.
Do	278	8.15	Do.
Do	278	8.06	Do.
Do	278	8.24	Do.
Do	278	7.92	Do.
TEST 3.			
Dec. 14	278		No ignition.
Do	278		Do.
Do	278		Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Dec. 14	278		No ignition.
Do	278		Do.
Do	278		Do.
Do	278		Do.
Do	278		Do.
Do	278		Do.
Do	278		Do.
TEST 4.			
Dec. 12	[a]680	4.37	No ignition.
Do	[a]680	4.42	Do.
Do	[a]680	4.17	Do.
Do	[a]680	4.29	Do.
Do	[a]680	4.11	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator No. 7.

Date (1911–12).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Dec. 30	18.60	44.0	2,366
Jan. 3	19.00	45.0	2,368
Do	19.60	45.0	2,296

Average rate of detonation, 2,343 meters (7,690 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 6	13.50	17.05	6.00	0.300
Do	10.00	12.63	5.25	.262
Do	9.00	11.37	3.75	.188

Average height of flame, 13.68 inches.
Average duration of flame, 0.250 millisecond.

IMPACT TEST.

Date, February 26, 1912.

Distance of fall.	Number of trials.	Result.
Centimeters.		
25	1	Explosion.
20	1	Do.
19	1	Do.
18	1	No explosion.
18	1	Explosion.
17	1	No explosion.
17	1	Explosion.
16	1	Do.
15	5	No explosion.

The maximum height at which no explosion occurs established at 15 centimeters (5.91 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 177 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Apr. 1	3	Did not explode.	Apr. 1	4	Did not explode.
Do	2	Exploded.	Do	4	Do.
Do	3	Do.	Apr. 2	4	Do.

The minimum distance at which no explosion occurs established at 4 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912.)	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Mar. 29	214	1.09	28.00	87.50	A	87.24
Apr. 1	214	1.09	28.00	87.50	A	
Do	214	1.09	27.75	86.72	A	
Apr. 2	214	1.09	24.75	77.34	B	75.52
Do	214	1.09	24.00	75.00	B	
Apr. 3	214	1.09	23.75	74.22	B	
Apr. 4	214	1.09	23.75	74.22	C	74.74
Do	214	1.09	24.00	75.00	C	
Do	214	1.09	24.00	75.00	C	

[a] Including 14 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=99.02$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.09$. $W=214.0$ grams.

$M=\frac{VPS}{W}=7{,}565$ kilograms per square centimeter (107,610 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 14 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, December 7, 1911.	Grams.
Solid	67.8
Liquid (water)	54.0
Gaseous	88.1

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 29	63.00	50.75	12.25
Do	63.50	51.50	12.00
Do	63.25	51.50	11.75

Average compression, 12.0 millimeters (0.47 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Feb. 26	62	188	126	15
Do	62	190	128	15
Do	62	188	126	15

Average expansion of bore hole, 127 cubic centimeters (7.75 cubic inches).

BENTAL COAL POWDER NO. 2.

Explosive, Bental coal powder No. 2.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Independent Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 174 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 1.04.
  Color of explosive, gray.
  Consistency, granular, fine, dry, soft, slightly cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, September 12, 1910.
  Unit swing on this date, 3.20 inches.
  Weight of charge, in grams, 270, 270, 270.
  Swing, in inches, 3.13, 3.07, 3.19.
  Average swing, in inches, 3.13.

3.13 : 3.20 : : 270 : (276).

Therefore the unit deflective charge of Bental coal powder No. 2 is 276 grams.

GAS AND DUST GALLERY NO. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Sept. 13	276	8.05	No ignition.
Do	276	7.90	Do.
Do	276	8.15	Do.
Do	276	8.09	Do.
Do	276	8.20	Do.
Do	276	8.17	Do.
Do	276	8.09	Do.
Do	276	8.17	Do.
Do	276	8.06	Do.
Do	276	7.87	Do.
TEST 3.			
Sept. 13	276	....	No ignition.
Do	276	....	Do.
Do	276	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Sept. 13	276	....	No ignition.
Do	276	....	Do.
Do	276	....	Do.
Do	276	....	Do.
Do	276	....	Do.
Do	276	....	Do.
Do	276	....	Do.
TEST 4.			
Sept. 12	[a] 680	4.16	No ignition.
Do	[a] 680	4.08	Do.
Do	[a] 680	4.03	Do.
Do	[a] 680	4.03	Do.
Do	[a] 680	4.13	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Sept. 12	30.52	43.5	1,425
Do	30.15	43.5	1,443
Do	29.55	43.5	1.472

Average rate of detonation, 1,447 meters (4,750 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 20	10.50	13.26	3.50	0.175
Do	12.25	15.47	5.50	.275
Do	8.50	10.74	3.50	.175

Average height of flame, 13.16 inches.
Average duration of flame, 0.208 millisecond.

IMPACT TEST.

Date, February 4, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
24	1	Explosion.	17	1	Explosion.
20	1	Do.	16	5	No explosion.
18	1	Do.			

The maximum height at which no explosion occurs established at 16 centimeters (6.3 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 166 grams.

Date (1913).	Distance separating cartridges.	Result, upper cartridge.	Date (1913).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Feb. 13	6	Did not explode.	Feb. 13	0	Exploded.
Do	4	Do.	Do	1	Do.
Do	2	Do.	Do	2	Did not explode.
Do	1	Do.	Do	2	Do.

The minimum distance at which no explosion occurs established at 2 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		Millimeters.	Kilograms.		Kilograms.
Feb. 8	214	1.03	27.25	85.16	A	84.64
Do	214	1.03	27.00	84.38	A	
Do	214	1.03	27.00	84.38	A	
Feb. 10	214	1.03	25.25	78.91	B	79.17
Do	214	1.03	25.00	78.12	B	
Do	214	1.03	25.75	80.47	B	
Do	214	1.03	24.25	75.78	C	75.52
Feb. 11	214	1.03	24.50	76.56	C	
Do	214	1.03	23.75	74.22	C	

[a] Including 14 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=94.77$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.03$. $W=214$ grams.

$M=\frac{VPS}{W}=6{,}842$ kilograms per square centimeter (97,320 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 16 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, January 27, 1911.	Grams.
Solid	42.7
Liquid (water)	67.0
Gaseous	94.4

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	Millimeters.	Millimeters.
Jan. 25	63.50	57.00	6.50
Do	63.50	57.25	6.25
Do	63.50	57.00	6.50

Average compression, 6.4 millimeters (0.25 inch.)

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	Cubic centimeters.	Cubic centimeters.	°C.
Jan. 27	63	158	95	15
Do	63	156	93	15
Do	63	160	97	15

Average expansion of bore hole, 95 cubic centimeters (5.80 cubic inches).

BITUMINITE NO. 1.

Explosive, Bituminite No. 1.
Class 4, nitroglycerin.
Manufactured by the Jefferson Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 223 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.37.
  Color of explosive, light corn.
  Consistency, fibrous, fine, dry, very soft, slightly cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, May 21, 1909.
  Unit swing on this date, 2.95 inches.
  Weight of charge, in grams, 310, 310, 310.
  Swing, in inches, 2.82, 2.94, 2.87.
  Average swing, in inches, 2.88.

2.88 : 2.95 :: 310 : (318).

Therefore the unit deflective charge of Bituminite No. 1 is 318 grams.

GAS AND DUST GALLERY NO. 1.

Date (1909).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
May 26	318	7.91	No ignition.
Do	318	8.01	Do.
Do	318	8.16	Do.
Do	318	8.16	Do.
Do	318	8.16	Do.
Do	318	8.29	Do.
Do	318	8.15	Do.
Do	318	8.13	Do.
Do	318	8.28	Do.
Do	318	8.10	Do.
TEST 3.			
May 25	318	....	No ignition.
Do	318	....	Do.
Do	318	....	Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
May 25	318	....	No ignition.
Do	318	....	Do.
Do	318	....	Do.
Do	318	....	Do.
Do	318	....	Do.
Do	318	....	Do.
Do	318	....	Do.
TEST 4.			
May 24	[a] 680	4.13	No ignition.
Do	[a] 680	4.21	Do.
Do	[a] 680	4.21	Do.
Do	[a] 680	4.05	Do.
Do	[a] 680	4.31	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1909).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Aug. 24	10.81	43.0	3,978
Do	11.03	43.0	3,898
Aug. 31	11.24	43.0	3,826

Average rate of detonation, 3,901 meters (12,800 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 14	21.25	26.84	9.00	0.450
Do	22.25	28.11	9.00	.450
Do	21.00	26.53	8.75	.438

Average height of flame, 27.16 inches.
Average duration of flame, 0.446 millisecond.

IMPACT TEST.

Date, January 3, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
24	1	Explosion.	16	1	No explosion.
22	1	Do.	16	1	Explosion.
20	1	Do.	15	1	Do.
16	1	No explosion.	13	1	Do.
18	1	Explosion.	12	5	No explosion.

The maximum height at which no explosion occurs established at 12 centimeters (4.72 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 216 grams.

Date (1910).	Distance separating cartridges.	Result, upper cartridge.	Date (1910).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Jan. 12	6	Exploded.	Jan. 13	15	Did not explode.
Do	9	Do.	Do	14	Do.
Jan. 13	13	Do.	Do	14	Do.
Do	17	Did not explode.	Do	14	Do.

The minimum distance at which no explosion occurs established at 14 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
May 15	214	1.23	24.75	77.34	A	78.38
May 16	214	1.23	25.75	80.47	A	
Do	214	1.23	24.75	77.34	A	
May 14	214	1.23	23.25	72.66	B	72.14
Do	214	1.23	23.25	72.66	B	
Do	214	1.23	22.75	71.09	B	
Do	214	1.23	22.25	69.53	C	69.79
Do	214	1.23	22.75	71.09	C	
May 16	214	1.23	22.00	68.75	C	

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[a] Including 14 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=87.38$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.23$ $W=214$ grams.

$M=\frac{VPS}{W}=7{,}533$ kilograms per square centimeter (107,140 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 14 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, May 21, 1913.	Grams.
Solid	54.0
Liquid (water)	15.0
Gaseous	125.2

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.0 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram
	Kilograms.	*° C.*	*Calories.*
May 14	81.95	0.867	749.5
Do	81.95	.903	781.0
May 15	81.95	.903	781.0

[a] Including 7 grams of the original wrapper.

Average large calories per kilogram of explosive, 770.5.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Feb. 19	63.50	47.50	16.00
Do	63.50	47.00	16.50
Feb. 23	63.50	47.00	16.50

Average compression, 16.3 millimeters (0.64 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Feb. 10	62	262	200	15
Do	62	261	199	15
Do	62	260	198	15

Average expansion of bore hole, 199 cubic centimeters (12.14 cubic inches).

BITUMINITE NO. 3.

Explosive, Bituminite No. 3.
Class 4, nitroglycerin.
Manufactured by the Jefferson Powder Co.
Physical examination:
  Diameter of cartridge, 1⅜ inches.
  Length of cartridge, 8½ inches.
  Average weight, 250 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.17.
  Color of explosive, corn.
  Consistency, fibrous, fine, dry, soft, slightly cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, November 7, 1910.
  Unit swing on this date, 3.16 inches.
  Weight of charge, in grams, 291, 291, 291.
  Swing, in inches, 3.14, 3.15, 3.11.
  Average swing, in inches, 3.13.

3.13 : 3.16 : : 291 : (294).

Therefore the unit deflective charge of Bituminite No. 3 is 294 grams.

GAS AND DUST GALLERY NO. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Nov. 7	294	7.79	No ignition.
Do	294	7.86	Do.
Do	294	7.98	Do.
Do	294	7.91	Do.
Nov. 8	294	8.19	Do.
Do	294	7.78	Do.
Do	294	7.89	Do.
Do	294	8.12	Do.
Do	294	8.00	Do.
Nov. 26	294	7.84	Do.
TEST 3.			
Nov 9	294	....	No ignition.
Do	294	....	Do.
Do	294	....	Do.
TEST 3—Con.			
	Grams.	*Per cent*	
Nov. 10	294	....	No ignition.
Do	294	....	Do.
Do	294	....	Do.
Do	294	....	Do.
Do	294	....	Do.
Do	294	....	Do.
Do	294	....	Do.
TEST 4.			
Nov. 11	[a] 680	4.02	No ignition.
Do	[a] 680	3.98	Do.
Do	[a] 680	3.92	Do.
Do	[a] 680	4.05	Do.
Do	[a] 680	4.03	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Nov. 14	15.32	43.5	2,839
Nov. 15	15.28	43.5	2,847
Do	15.30	43.5	2,843

Average rate of detonation, 2,843 meters (9,330 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
July 7	14.00	17.68	6.25	0.312
Do	11.00	13.89	4.75	.238
Do	9.75	12.32	4.25	.212

Average height of flame, 14.63 inches.
Average duration of flame, 0.254 millisecond.

IMPACT TEST.

Date, June 14, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	11	1	Explosion.
18	1	Do.	10	1	No explosion.
16	1	Do.	10	1	Explosion.
14	1	Do.	9	5	No explosion.
13	1	Do.			

The maximum height at which no explosion occurs established at 9 centimeters (3.54 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 188 grams.

Date (1911).	Distance separating cartridges	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
July 18	8	Did not explode.	July 18	5	Did not explode.
Do	4	Exploded.	Do	5	Do.
Do	6	Did not explode.	Do	5	Do.

The minimum distance at which no explosion occurs established at 5 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
June 8	215	1.17	23.50	73.44	A	72.66
Do	215	1.17	22.75	71.09	A	
Do	215	1.17	23.50	73.44	A	
June 6	215	1.17	21.00	65.62	B	65.36
June 7	215	1.17	21.00	65.62	B	
Do	215	1.17	20.75	64.84	B	
Do	215	1.17	19.50	60.94	C	61.98
Do	215	1.17	19.75	61.72	C	
Do	215	1.17	20.25	63.28	C	

[a] Including 15 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=84.08$ kilograms per square centimeter.
$V=15{,}000$ cubic centimeters. $S=1.17$. $W=215$ grams.

$M=\frac{VPS}{W}=6{,}863$ kilograms per square centimeter (97,620 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 15 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 7, 1911.	Grams.
Solid	63. 8
Liquid (water)	18. 7
Gaseous	121. 8

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.5 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
July 14	80. 95	0. 811	689. 9
Do	80. 95	. 834	709. 6
Do	80. 95	. 842	716. 4

[a] Including 7.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 705.3.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters*
July 17	63. 50	49. 25	14. 25
Do	63. 75	49. 50	14. 25
Do	63. 50	49. 50	14. 00

Average compression, 14.2 millimeters (0.56 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Apr. 3	63	222	159	15
Do	63	221	158	15
Do	63	222	159	15

Average expansion of bore hole, 159 cubic centimeters (9.70 cubic inches).

BITUMINITE NO. 4.

Explosive, Bituminite No. 4.
Class 4, nitroglycerin.
Manufactured by the Jefferson Powder Co.
Physical examination:
  Diameter of cartridge, 1⅜ inches.
  Length of cartridge, 8⅛ inches.
  Average weight, 236 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.14.
  Color of explosive, drab.
  Consistency, fibrous, fine, dry, soft, slightly cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, November 7, 1910.
  Unit swing on this date, 3.16 inches.
  Weight of charge, in grams, 305, 305, 305.
  Swing, in inches, 3.27, 3.16, 3.16.
  Average swing, in inches, 3.20.

$$3.20 : 3.16 :: 305 : (301).$$

Therefore the unit deflective charge of Bituminite No. 4 is 301 grams.

Gas and Dust Gallery No. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.	Date (1910).	Weight of charge.	Methane and ethane.	Result.
Test 1.				Test 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Nov. 8	301	7.86	No ignition.	Nov. 10	301	....	No ignition.
Do	301	7.90	Do.	Do	301	....	Do.
Do	301	7.77	Do.	Do	301	....	Do.
Do	301	8.00	Do.	Do	301	....	Do.
Do	301	7.84	Do.	Do	301	....	Do.
Do	301	7.84	Do.	Do	301	....	Do.
Do	301	7.79	Do.	Do	301	....	Do.
Do	301	7.93	Do.	Do	301	....	Do.
Do	301	8.11	Do.				
Do	301	7.97	Do.	Test 4.			
Test 3.				Nov. 11	[a] 680	4.09	No ignition.
				Do	[a] 680	4.00	Do.
Nov. 10	301	....	No ignition.	Do	[a] 680	3.89	Do.
Do	301	....	Do.	Do	[a] 680	4.01	Do.
Do	301	....	Do.	Do	[a] 680	4.06	Do.

[a] 680 grams or more was used.

Rate of Detonation.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Nov. 15	18.82	43.5	2,311
Do	18.80	43.5	2,314
Do	19.17	43.5	2,269

Average rate of detonation, 2,298 meters (7,540 feet) per second.

Flame Test.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
July 7	8.00	10.11	3.50	0.175
Do	10.00	12.63	5.25	.262
Do	10.25	12.95	4.75	.238

Average height of flame, 11.90 inches.
Average duration of flame, 0.225 millisecond.

Impact Test.

Date, June 15, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	13	1	Explosion.
12	1	No explosion.	12	1	Do.
16	1	Explosion.	11	3	No explosion.
14	1	Do.	11	1	Explosion.
13	2	No explosion.	10	5	No explosion.

The maximum height at which no explosion occurs established at 10 centimeters (3.94 inches).

Explosion-by-Influence Test.

Weight of each cartridge, 184 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
July 18	5	Exploded.	July 18	6	Did not explode.
Do	7	Did not explode.	Do	6	Do.
Do	6	Do.			

The minimum distance at which no explosion occurs established at 6 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
June 8	215	1.14	19.00	59.37	A	58.84
Do	215	1.14	18.75	58.58	A	
Do	215	1.14	18.75	58.58	A	
Do	215	1.14	17.50	54.69	B	55.73
June 9	215	1.14	18.00	56.25	B	
Do	215	1.14	18.00	56.25	B	
June 7	215	1.14	18.00	56.25	C	55.99
Do	215	1.14	17.75	55.47	C	
June 8	215	1.14	18.00	56.25	C	

[a] Including 15 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=61.31$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.14$. $W=215$ grams.

$M=\frac{VPS}{W}=4{,}876$ kilograms per square centimeter (69,360 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 15 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 8, 1911.	Grams.
Solid	78.2
Liquid (water)	13.5
Gaseous	119.5

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.5 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°C.	*Calories.*
July 15	80.95	0.736	625.3
Do	80.95	.733	622.7
July 17	80.95	.706	599.5

[a] Including 7.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 615.8.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
July 17	63.50	53.25	10.25
Do	63.50	53.75	9.75
Do	63.50	53.50	10.00

Average compression, 10.0 millimeters (0.39 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°C.
Apr. 3	63	172	109	15
Do	63	170	107	15
Do	63	168	105	15

Average expansion of bore hole, 107 cubic centimeters (6.53 cubic inches).

BITUMINITE NO. 5.

Explosive, Bituminite No. 5.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Jefferson Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 7¾ inches.
  Average weight, 173 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.08.
  Color of explosive, corn.
  Consistency, granular, fine, dry, soft, slightly cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, November 7, 1910.
  Unit swing on this date, 3.16 inches.
  Weight of charge, in grams, 240, 240, 240.
  Swing, in inches, 3.30, 3.35, 3.21.
  Average swing, in inches, 3.29.

3.29 : 3.16 : : 240 : (231).

Therefore the unit deflective charge of Bituminite No. 5 is 231 grams.

GAS AND DUST GALLERY NO. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Nov. 8	231	7.96	No ignition.
Do	231	7.98	Do.
Do	231	8.13	Do.
Do	231	7.95	Do.
Do	231	8.02	Do.
Do	231	8.03	Do.
Do	231	7.80	Do.
Do	231	7.96	Do.
Do	231	8.13	Do.
Do	231	8.00	Do.
TEST 3.			
Nov. 10	231	....	No ignition.
Do	231	....	Do.
Do	231	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Nov. 10	231	....	No ignition.
Do	231	....	Do.
Nov. 11	231	....	Do.
Do	231	....	Do.
Do	231	....	Do.
Do	231	....	Do.
Do	231	....	Do.
TEST 4.			
Nov. 11	[a]680	4.01	No ignition.
Do	[a]680	4.04	Do.
Do	[a]680	3.97	Do.
Do	[a]680	3.95	Do.
Nov. 14	[a]680	3.99	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Nov. 7	15.90	45.0	2,830
Nov. 8	16.13	45.0	2,790
Do	16.50	45.0	2,727

Average rate of detonation, 2,782 meters (9,120 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
July 8	13.25	16.74	5.50	0.275
Do	13.00	16.42	4.75	.238
Do	11.75	14.84	4.00	.200

Average height of flame, 16.00 inches.
Average duration of flame, 0.238 millisecond.

IMPACT TEST.

Date, June 15, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
16	1	No explosion.	16	1	Explosion.
20	1	Explosion.	15	1	Do.
18	1	Do.	14	4	No explosion.
14	1	No explosion.			

The maximum height at which no explosion occurs established at 14 centimeters (5.51 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 174 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
July 19	2	Exploded.	July 19	4	Did not explode.
Do	4	Did not explode.	Do	4	Do.
Do	3	Exploded.			

The minimum distance at which no explosion occurs established at 4 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
June 14	214	1.08	31.50	98.44	A	97.66
Do	214	1.08	31.25	97.66	A	
Do	214	1.08	31.00	96.88	A	
June 9	214	1.08	29.75	92.97	B	92.71
Do	214	1.08	30.25	94.53	B	
June 21	214	1.08	29.00	90.62	B	
June 10	214	1.08	28.25	88.28	C	88.54
Do	214	1.08	28.00	87.50	C	
June 20	214	1.08	28.75	89.84	C	

[a] Including 14 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=108.05$ kilograms per square centimeter.
$V=15{,}000$ cubic centimeters. $S=1.08$. $W=214$ grams.
$M=\frac{VPS}{W}=8{,}179$ kilograms per square centimeter (116,340 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 21 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 9, 1911.	Grams.
Solid	14.3
Liquid (water)	81.0
Gaseous	112.9

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.0 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
July 18	80.95	1.336	1,146.9
Do	80.95	1.307	1,121.9
Do	80.95	1.342	1,152.1

[a] Including 7 grams of the original wrapper.

Average large calories per kilogram of explosive, 1,140.3.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Aug. 11	63.25	51.00	12.25
Do	63.50	51.00	12.50
Do	63.50	51.00	12.50

Average compression, 12.4 millimeters (0.49 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Apr. 3	63	226	163	15
Do	63	220	157	15
Do	63	220	157	15

Average expansion of bore hole, 159 cubic centimeters (9.70 cubic inches).

BLACK DIAMOND NO. 2-A.

Explosive, Black Diamond No. 2-A.
Class 4, nitroglycerin.
Manufactured by the Illinois Powder Manufacturing Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 196 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.17.
  Color of explosive, corn.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.
Unit deflective charge as determined by ballistic pendulum:
  Date, January 29, 1912.
  Unit swing on this date, 3.62 inches.
  Weight of charge, in grams, 280, 280, 280.
  Swing, in inches, 3.63, 3.66, 3.53.
  Average swing, in inches, 3.61.

$$3.61 : 3.62 :: 280 : (281).$$

Therefore the unit deflective charge of Black Diamond No. 2-A is 281 grams.

GAS AND DUST GALLERY NO. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Jan. 31	281	7.87	No ignition.	Feb. 5	281	....	No ignition.
Do	281	8.28	Do.	Do	281	....	Do.
Do	281	8.69	Do.	Do	281	....	Do.
Do	281	8.00	Do.	Do	281	....	Do.
Do	281	8.22	Do.	Do	281	....	Do.
Do	281	8.49	Do.	Do	281	....	Do.
Do	281	7.88	Do.	Feb. 6	281	....	Do.
Do	281	7.99	Do.				
Do	281	8.19	Do.	TEST 4.			
Do	281	7.95	Do.				
				Feb. 2	[a] 680	4.24	No ignition.
TEST 3.				Do	[a] 680	4.10	Do.
				Do	[a] 680	3.95	Do.
Feb. 5	281	....	No ignition.	Do	[a] 680	3.88	Do.
Do	281	....	Do.	Do	[a] 680	4.02	Do.
Do	281	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Jan. 30	11.50	44.5	3,819
Feb. 5	11.70	45.0	3,846
Feb. 6	11.40	44.0	3,860

Average rate of detonation, 3,842 meters (12,600 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 30	12.75	16.11	5.00	0.250
Do	13.00	16.42	4.75	.238
June 4	8.00	10.11	1.75	.088

Average height of flame, 14.21 inches.
Average duration of flame, 0.192 millisecond.

IMPACT TEST.

Date, April 19, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	15	1	No explosion.
18	1	Do.	17	5	Do.

The maximum height at which no explosion occurs established at 17 centimeters (6.69 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 188 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
May 1	3	Exploded.	May 1	6	Exploded.
Do	5	Do.	Do	7	Did not explode.
Do	9	Did not explode.	Do	7	Do.
Do	7	Do.			

The minimum distance at which no explosion occurs established at 7 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Apr. 18	213	1.17	20.25	63.28	A	63.80
Apr. 19	213	1.17	20.50	64.06	A	
Do	213	1.17	20.50	64.06	A	
Apr. 22	213	1.17	19.50	60.94	B	62.76
Do	213	1.17	20.25	63.28	B	
Do	213	1.17	20.50	64.06	B	
Apr. 19	213	1.17	18.25	57.03	C	57.81
Do	213	1.17	18.25	57.03	C	
Do	213	1.17	19.00	59.38	C	

[a] Including 13 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=71.73$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.17$. $W=213$ grams.

$M=\frac{VPS}{W}=5{,}910$ kilograms per square centimeter (84,060 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 13 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, January 29, 1912.	Grams.
Solid	66.9
Liquid (water)	13.0
Gaseous	124.3

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°C.	*Calories.*
Apr. 8	81.95	0.871	756.6
Apr. 9	81.95	.842	731.2
Apr. 13	81.95	.849	737.3

[a] Including 6.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 741.7.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Apr. 17	63.25	46.25	17.00
Do	63.00	46.00	17.00
Do	63.25	46.25	17.00

Average compression, 17.0 millimeters (0.67 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°C.
Apr 15	63	220	157	19
Do	63	226	163	19
Do	63	228	165	19

Average expansion of bore hole, 162 cubic centimeters (9.88 cubic inches).

BLACK DIAMOND NO. 3-A.

Explosive, Black Diamond No. 3-A.
Class 4, nitroglycerin.
Manufactured by the Illinois Powder Manufacturing Co.
Physical examination:
- Diameter of cartridge, 1¼ inches.
- Length of cartridge, 8 inches.
- Average weight, 183 grams.
- Cartridge had not been redipped.
- Apparent specific gravity of cartridge by sand, 1.09.
- Color of explosive, corn.
- Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by ballistic pendulum:
- Date, January 29, 1912.
- Unit swing on this date, 3.62 inches.
- Weight of charge, in grams, 290, 290, 290.
- Swing, in inches, 3.63, 3.54, 3.55.
- Average swing, in inches, 3.57.

3.57 : 3.62 : : 290 : (294).

Therefore the unit deflective charge of Black Diamond No. 3-A is 294 grams.

GAS AND DUST GALLERY NO. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Jan. 31	294	7.81	No ignition.
Do	294	7.91	Do.
Do	294	8.29	Do.
Do	294	8.41	Do.
Feb. 1	294	8.39	Do.
Do	294	8.12	Do.
Do	294	8.31	Do.
Do	294	8.72	Do.
Do	294	7.82	Do.
Do	294	8.28	Do.
TEST 3.			
Feb. 6	294		No ignition.
Do	294		Do.
Do	294		Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Feb. 6	294		No ignition.
Do	294		Do.
Do	294		Do.
Do	294		Do.
Do	294		Do.
Do	294		Do.
Do	294		Do.
TEST 4.			
Feb. 5	[a] 680	3.79	No ignition.
Do	[a] 680	3.88	Do.
Do	[a] 680	3.98	Do.
Do	[a] 680	4.02	Do.
Do	[a] 680	3.91	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Jan. 31	12.85	44.0	3,424
Feb. 5	13.10	44.0	3,359
Feb. 6	12.85	44.0	3,423

Average rate of detonation, 3,402 meters (11,160 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 30	16.00	20.21	6.00	0.300
Do	13.00	16.42	6.50	.325
Do	13.00	16.42	4.25	.212

Average height of flame, 17.68 inches.
Average duration of flame, 0.279 millisecond.

IMPACT TEST.

Date, April 19, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	No explosion.	24	1	Explosion.
25	1	Explosion.	22	1	Do.
24	1	No explosion.	21	5	No explosion.

The maximum height at which no explosion occurs established at 21 centimeters (8.27 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 175 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
May 2	7	Did not explode.	May 2	4	Did not explode.
Do	3	Exploded.	Do	4	Do.
Do	5	Did not explode.	Do	4	Do.

The minimum distance at which no explosion occurs established at 4 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Apr. 22	213	1.09	21.00	65.62	A	67.71
May 2	213	1.09	22.00	68.75	A	
Do	213	1.09	22.00	68.75	A	
Apr. 23	213	1.09	20.50	64.06	B	63.02
Do	213	1.09	19.50	60.94	B	
Apr. 24	213	1.09	20.50	64.06	B	
Do	213	1.09	19.25	60.16	C	60.42
Do	213	1.09	19.25	60.16	C	
Do	213	1.09	19.50	60.94	C	

[a] Including 13 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=75.65$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.09$. $W=213$ grams.

$M=\frac{VPS}{W}=5{,}807$ kilograms per square centimeter (82,590 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 13 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, January 30, 1912.

	Grams.
Solid	75.0
Liquid (water)	11.5
Gaseous	119.2

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°*C.*	*Calories.*
Apr. 12	81.95	0.884	768.0
Do	81.95	.850	738.2
Apr. 15	81.95	.887	770.6

[a] Including 6.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 758.9.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Apr. 17	63.25	48.50	14.75
Do	63.25	48.75	14.50
Do	63.25	49.00	14.25

Average compression, 14.5 millimeters (0.57 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Apr. 15	63	228	165	19
Do	63	231	168	19
Do	63	228	165	19

Average expansion of bore hole, 166 cubic centimeters (10.13 cubic inches).

BLACK DIAMOND NO. 5.

Explosive, Black Diamond No. 5.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Illinois Powder Manufacturing Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 179 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.10.
  Color of explosive, corn.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.
Unit deflective charge as determined by ballistic pendulum:
  Date, January 29, 1912.
  Unit swing on this date, 3.62 inches.
  Weight of charge, in grams, 300, 300, 300.
  Swing, in inches, 3.71, 3.82, 3.77.
  Average swing, in inches, 3.77.

$$3.77 : 3.62 :: 300 : (288).$$

Therefore the unit deflective charge of Black Diamond No. 5 is 288 grams.

GAS AND DUST GALLERY NO. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Feb. 1	288	8.13	No ignition.	Feb. 6	288	....	No ignition.
Do	288	8.22	Do.	Do	288	....	Do.
Do	288	7.99	Do.	Do	288	....	Do.
Do	288	8.17	Do.	Do	288	....	Do.
Do	288	8.27	Do.	Do	288	....	Do.
Feb. 2	288	8.23	Do.	Do	288	....	Do.
Do	288	8.16	Do.	Do	288	....	Do.
Do	288	7.97	Do.				
Do	288	8.36	Do.	TEST 4.			
Do	288	8.25	Do.				
				Feb. 2	[a] 680	4.05	No ignition.
TEST 3.				Feb. 3	[a] 680	4.00	Do.
				Do	[a] 680	4.11	Do.
Feb. 6	288	....	No ignition.	Do	[a] 680	4.07	Do.
Do	288	....	Do.	Do	[a] 680	4.21	Do.
Do	288	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Jan. 30	24.10	44.5	1,847
Feb. 5	24.45	44.5	1,820
Feb. 6	24.20	44.5	1,839

Average rate of detonation, 1,835 meters (6,020 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
May 16	7.00	8.84	2.50	0.125
Do	8.25	10.42	4.00	.200
Do	3.50	4.42	1.50	.075

Average height of flame, 7.89 inches.
Average duration of flame, 0.133 millisecond.

IMPACT TEST.

Date, March 5, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	No explosion.	17	2	No explosion.
20	1	Explosion.	17	1	Explosion.
18	3	No explosion.	16	5	No explosion.
18	1	Explosion.			

The maximum height at which no explosion occurs established at 16 centimeters (6.30 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 177 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
May 2	7	Did not explode.	May 2	2	Did not explode.
Do	3	Do.	Do	2	Do.
Do	1	Exploded.	Do	2	Do.

The minimum distance at which no explosion occurs established at 2 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Apr. 25	213	1.10	30.25	94.53	A	93.23
Do	213	1.10	29.50	92.19	A	
Do	213	1.10	29.75	92.97	A	
Do	213	1.10	25.75	80.47	B	81.77
Do	213	1.10	26.75	83.59	B	
Do	213	1.10	26.00	81.25	B	
Apr. 24	213	1.10	23.75	74.22	C	73.44
Do	213	1.10	23.75	74.22	C	
Do	213	1.10	23.00	71.88	C	

[a] Including 13 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=115.42$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.10$. $W=213$ grams.

$M=\frac{VPS}{W}=8{,}941$ kilograms per square centimeter (127,170 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 13 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, January 30, 1912.	Grams.
Solid	33.7
Liquid (water)	61.5
Gaseous	106.2

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Apr. 17	63.25	53.50	9.75
Do	63.25	53.75	9.50
Do	63.25	53.75	9.50

Average compression, 9.6 millimeters (0.38 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Apr. 25	62	206	144	19
Do	62	200	138	19
Do	62	204	142	19

Average expansion of bore hole, 141 cubic centimeters (8.60 cubic inches).

CAMERON MINE POWDER NO. 1-A.

Explosive, Cameron mine powder No. 1-A.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Cameron Powder Manufacturing Co
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 148 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 0.90.
  Color of explosive, corn.
  Consistency, granular and fibrous, fine, very dry, very soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, March 7, 1911.
Unit swing on this date, 3.13 inches.
Weight of charge, in grams, 220, 220, 220.
Swing, in inches, 3.04, 3.11, 2.97.
Average swing, in inches, 3.04.

3.04 : 3.13 : : 220 : (227).

Therefore the unit deflective charge of Cameron mine powder No. 1–A is 227 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Mar. 8	227	7.94	No ignition.
Do	227	7.80	Do.
Mar. 9	227	7.83	Do.
Do	227	7.93	Do.
Do	227	7.93	Do.
Do	227	8.25	Do.
Do	227	7.78	Do.
Do	227	8.11	Do.
Do	227	8.14	Do.
Mar. 10	227	7.93	Do.
TEST 3.			
Mar. 14	227		No ignition.
Do	227		Do.
Do	227		Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Mar. 14	227		No ignition.
Do	227		Do.
Do	227		Do.
Do	227		Do.
Do	227		Do.
Do	227		Do.
Do	227		Do.
TEST 4.			
Mar. 8	[a] 680	3.93	No ignition.
Mar. 20	[a] 680	4.07	Do.
Do	[a] 680	4.14	Do.
Do	[a] 680	3.93	Do.
Do	[a] 680	3.97	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Mar. 7	13.56	45.0	3,319
Do	13.30	45.0	3,383
Do	13.58	45.0	3,314

Average rate of detonation, 3,339 meters (10,950 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Sept. 28	7.00	8.84	2.00	0.100
Do	7.50	9.47	2.00	.100
Do	8.75	11.05	3.00	.150

Average height of flame, 9.79 inches.
Average duration of flame, 0.117 millisecond.

IMPACT TEST.

Date, July 28, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	12	1	Explosion.
14	1	Do.	10	1	Do.
8	1	No explosion.	9	5	No explosion.
10	1	Do.			

The maximum height at which no explosion occurs established at 9 centimeters (3.54 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 152 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Oct. 2	4	Did not explode.	Oct. 2	3	Did not explode.
Do	3	Do.	Do	3	Do.
Do	2	Exploded.			

The minimum distance at which no explosion occurs established at 3 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Oct. 4	215	0.96	31.00	96.88	A	98.18
Oct. 5	215	.96	32.00	100.00	A	
Do	215	.96	31.25	97.66	A	
Oct. 6	215	.94	31.25	97.66	B	94.79
Do	215	.94	30.00	93.75	B	
Oct. 7	215	.94	29.75	92.97	B	
Do	215	.94	28.75	89.84	C	90.62
Oct. 9	215	.94	28.75	89.84	C	
Do	215	.94	29.50	92.19	C	

[a] Including 15 grams of the original wrapper.

P=1.911A+0.5B−1.411C=107.15 kilograms per square centimeter.

V=15,000 cubic centimeters. S=0.90. W=215.0 grams.

$M=\frac{VPS}{W}$=6.729 kilograms per square centimeter (95,710 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 15 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 23, 1911.

	Grams.
Solid	9.6
Liquid (water)	66.5
Gaseous	129.6

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.3 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*°C.*	*Calories.*
Jan. 29	81.95	1.267	1,096.0
Jan. 30	81.95	1.227	1,061.1
Do	81.95	1.248	1,079.5

[a] Including 7.3 grams of the original wrapper.

Average large calories per kilogram of explosive, 1,078.9.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Sept. 23	63.25	46.00	17.25
Do	63.50	46.00	17.50
Do	63.50	46.50	17.00

Average compression, 17.2 millimeters (0.68 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCK.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Apr. 11	63	371	308	15
Do	63	376	313	15
Do	63	383	320	15

Average expansion of bore hole, 314 cubic centimeters (19.15 cubic inches).

CAMERON MINE POWDER NO. 2-A.

Explosive, Cameron mine powder No. 2-A.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Cameron Powder Manufacturing Co.
Physical examination:
    Diameter of cartridge, 1¼ inches.
    Length of cartridge, 8 inches.
    Average weight, 157 grams.
    Cartridge had not been redipped.
    Apparent specific gravity of cartridge by sand, 0.94.
    Color of explosive, gray.
    Consistency, granular and fibrous, fine, very dry, very soft, slightly cohesive,

Unit deflective charge as determined by the ballistic pendulum:

Date, March 7, 1911.
Unit swing on this date, 3.13 inches.
Weight of charge, in grams, 220, 220, 220.
Swing, in inches, 3.05, 2.98, 2.97.
Average swing, in inches, 3.00.

3.00 : 3.13 : : 220 : (230).

Therefore the unit deflective charge of Cameron mine powder No. 2-A is 230 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Mar. 9	230	8.04	No ignition.
Do	230	8.21	Do.
Do	230	7.82	Do.
Do	230	7.99	Do
Do	230	8.03	Do.
Do	230	7.87	Do.
Do	230	8.06	Do.
Mar. 10	230	7.86	Do.
Do	230	8.05	Do.
Do	230	8.06	Do.
TEST 3.			
Mar. 14	230	....	No ignition.
Do	230	....	Do.
Do	230	....	Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Mar. 14	230	....	No ignition.
Do	230	....	Do.
Do	230	....	Do.
Do	230	....	Do.
Do	230	....	Do.
Do	230	....	Do.
Do	230	....	Do.
TEST 4.			
Mar. 16	[a] 680	3.97	No ignition.
Do	[a] 680	3.82	Do.
Do	[a] 680	3.88	Do.
Do	[a] 680	3.99	Do.
Do	[a] 680	3.94	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1½ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Mar. 23	14.32	45.0	3,142
Mar. 31	14.18	45.0	3,173
Do	13.63	45.0	3,302

Average rate of detonation, 3,206 meters (10,520 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911–12).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Sept. 28	10.75	13.58	3.50	0.175
Do	7.50	9.47	2.00	.100
Jan. 3	16.25	20.53	6.50	.325

Average height of flame, 14.53 inches.
Average duration of flame, 0.200 millisecond.

IMPACT TEST.

Date, July 29, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
30	1	Explosion.	15	1	Explosion.
20	1	Do.	14	1	Do.
16	1	No explosion.	13	1	Do.
18	1	Explosion.	12	5	No explosion.
16	1	Do.			

The maximum height at which no explosion occurs established at 12 centimeters (4.72 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 160 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Oct. 2	3	Did not explode.	Oct. 3	½	Exploded.
Do	2	Do.	Do	1	Did not explode.
Do	1	Do.	Do	1	Do.
Do	0	Exploded.			

The minimum distance at which no explosion occurs established at 1 inch.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Oct. 10	214	0.94	30.75	96.09	A	96.09
Oct. 11	214	.94	30.00	93.75	A	
Do	214	.94	31.50	98.44	A	
Oct. 10	214	.94	28.00	87.50	B	87.24
Do	214	.94	27.75	86.72	B	
Do	214	.94	28.00	87.50	B	
Oct. 9	214	.94	27.50	85.94	C	86.20
Do	214	.94	27.00	84.38	C	
Oct. 10	214	.94	28.25	88.28	C	

[a] Including 14 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=105.62$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=0.94$. $W=214$ grams.

$$M=\frac{VPS}{W}=6{,}959$$ kilograms per square centimeter (98,990 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 14 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 23, 1911.

	Grams.
Solid	12.4
Liquid (water)	63.5
Gaseous	130.4

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.0 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Jan. 19	81.95	1.156	1,002.1
Do	81.95	1.170	1,014.4
Jan. 20	81.95	1.147	994.2

[a] Including 7 grams of the original wrapper.

Average large calories per kilogram of explosive, 1,003.6.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Sept. 23	63.50	51.25	12.25
Do	63.75	51.50	12.25
Do	63.50	51.50	12.00

Average compression, 12.2 millimeters (0.48 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCK.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Apr. 11	63	362	299	15
Do	63	355	292	15
Do	63	357	294	15

Average expansion of bore hole, 295 cubic centimeters (18 cubic inches).

CAMERON MINE POWDER NO. 2-A, L. F.

Explosive, Cameron mine powder No. 2-A, L. F.

Class 1*a*, ammonium nitrate, containing nitroglycerin.

Manufactured by the Cameron Powder Manufacturing Co.

Physical examination:

Diameter of cartridge, 1¼ inches.

Length of cartridge, 8 inches.

Average weight, 183 grams.

Cartridge had not been redipped.

Apparent specific gravity of cartridge by sand, 1.18.

Color of explosive, corn.

Consistency, granular, very fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, September 25, 1911.

Unit swing on this date, 3.41 inches.

Weight of charge, in grams, 235, 235, 235.

Swing, in inches, 3.47, 3.43, 3.42.

Average swing, in inches, 3.44.

3.44 : 3.41 : : 235 : (233).

Therefore the unit deflective charge of Cameron mine powder No. 2-A, L. F., is 233 grams.

Gas and Dust Gallery No. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
Test 1.	*Grams.*	*Per cent.*	
Sept. 27	233	8.23	No ignition.
Do	233	8.15	Do.
Do	233	8.30	Do.
Do	233	8.35	Do.
Do	233	8.03	Do.
Do	233	8.34	Do.
Sept. 28	233	8.09	Do.
Do	233	7.90	Do.
Do	233	8.12	Do.
Do	233	8.23	Do.
Test 3.			
Sept. 29	233		No ignition.
Do	233		Do.
Do	233		Do.
Test 3—Con.			
Sept. 29	233		No ignition.
Sept. 30	233		Do.
Do	233		Do.
Do	233		Do.
Oct. 2	233		Do.
Do	233		Do.
Do	233		Do.
Test 4.			
Sept. 28	[a] 680	4.25	No ignition.
Do	[a] 680	4.28	Do.
Do	[a] 680	4.11	Do.
Do	[a] 680	4.09	Do.
Do	[a] 680	4.06	Do.

[a] 680 grams or more was used.

Rate of Detonation.

Diameter of cartridge, 1¼ inches.

Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Sept. 26	13.42	45.0	3,353
Sept. 27	13.21	45.0	3,407
Do	13.83	45.0	3,254

Average rate of detonation, 3,338 meters (10,950 feet) per second.

Flame Test.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Jan. 28	9.75	12.32	5.00	0.250
Do	5.75	7.26	2.75	.138
Do	9.75	12.32	5.75	.288

Average height of flame, 10.63 inches.

Average duration of flame, 0.225 millisecond.

IMPACT TEST.

Date, November 9, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
8	1	No explosion.	28	1	No explosion.
16	1	Do.	30	1	Do.
32	1	Explosion.	31	1	Explosion.
24	1	No explosion.	30	4	No explosion.

The maximum height at which no explosion occurs established at 30 centimeters (11.81 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 179 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Dec. 12	6	Did not explode.	Dec. 12	3	Did not explode.
Do	4	Do.	Do	3	Do.
Do	2	Exploded.	Do	3	Do.

The minimum distance at which no explosion occurs established at 3 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.40 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Jan. 29	106.5	1.11	20.75	51.88	A	53.13
Jan. 30	106.5	1.11	21.50	53.75	A	
Do	106.5	1.11	21.50	53.75	A	
Do	106.5	1.11	19.00	47.50	B	48.13
Do	106.5	1.11	19.00	47.50	B	
Do	106.5	1.11	19.75	49.38	B	
Do	106.5	1.11	19.25	48.12	C	47.91
Do	106.5	1.11	19.00	47.50	C	
Do	106.5	1.11	19.25	48.12	C	

[a] Including 6.5 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=58.00$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=1.11$. $W=106.5$ grams.

$M=\frac{VPS}{W}=9.068$ kilograms per square centimeter (128,980 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 13 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

December 9, 1912.

	Grams.
Solid	18.7
Liquid (water)	73.0
Gaseous	105.5

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.5 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Jan. 20	81.95	1.369	1,193.8
Do	81.95	1.364	1,189.4
Feb. 21	81.95	1.330	1,159.6

[a] Including 6.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 1,180.9.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1913).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Jan. 27	63.25	50.00	13.25
Do	63.50	50.25	13.25
Do	63.75	50.00	13.75

Average compression, 13.4 millimeters (0.53 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCK.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Nov. 15	63	266	203	15
Do	63	260	197	15
Do	63	270	207	15

Average expansion of bore hole, 202 cubic centimeters (12.32 cubic inches).

CAMERON MINE POWDER NO. 3-A.

Explosive, Cameron mine powder No. 3–A.
Class 4, nitroglycerin.
Manufactured by the Cameron Powder Manufacturing Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 176 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.03.
  Color of explosive, corn.
  Consistency, fibrous, fine, very dry, very soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, March 7, 1911.
Unit swing on this date, 3.13 inches.
Weight of charge, in grams, 310, 310, 310.
Swing, in inches, 3.24, 3.28, 3.32,
Average swing, in inches, 3.28.

$$3.28 : 3.13 :: 310 : (296).$$

Therefore the unit deflective charge of Cameron mine powder No. 3-A is 296 grams.

GAS AND DUST GALLERY No. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Mar. 11	296	7.99	No ignition.
Do	296	8.06	Do.
Do	396	7.79	Do.
Do	296	8.07	Do.
Do	296	7.98	Do.
Do	296	8.11	Do.
Do	296	8.08	Do.
Mar. 13	296	7.87	Do.
Do	296	7.80	Do.
Do	296	8.02	Do.
TEST 3.			
Mar. 15	296	....	No ignition.
Do	296	....	Do.
Do	296	....	Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Mar. 15	296	....	No ignition.
Do	296	....	Do.
Do	296	....	Do.
Do	296	....	Do.
Do	296	....	Do.
Do	296	....	Do.
Do	296	....	Do.
TEST 4.			
Mar. 18	[a] 680	4.15	No ignition.
Do	[a] 680	4.01	Do.
Mar. 20	[a] 680	4.06	Do.
Do	[a] 680	4.03	Do.
Do	[a] 680	4.03	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Mar. 8	13.73	45.0	3,277
Mar. 10	13.28	45.0	3,389
Do	13.50	45.0	3,333

Average rate of detonation, 3,333 meters (10,930 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Jan. 3	15.50	19.58	6.75	0.338
Do	17.50	22.11	7.50	.375
Do	17.75	22.42	7.00	.350

Average height of flame, 21.37 inches.
Average duration of flame, 0.354 millisecond.

IMPACT TEST.

Date, July 24, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	13	1	Explosion.
16	1	Do.	12	1	No explosion.
12	1	No explosion.	12	1	Explosion.
15	1	Explosion.	11	5	No explosion.
14	1	Do.			

The maximum height at which no explosion occurs established at 11 centimeters (4.33 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 175 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Oct. 3	4	Did not explode.	Oct. 3	5	Did not explode.
Do	2	Exploded.	Do	5	Do.
Do	3	Do.	Do	5	Do.
Do	4	Do.			

The minimum distance at which no explosion occurs established at 5 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Oct. 11	213	1.03	21.25	66.41	A	65.37
Do	213	1.03	21.25	66.41	A	
Oct. 12	213	1.03	20.25	63.28	A	
Do	213	1.03	20.75	64.84	B	66.15
Do	213	1.03	21.25	66.41	B	
Oct. 13	213	1.03	21.50	67.19	B	
Do	213	1.03	21.25	66.41	C	65.63
Do	213	1.03	21.25	66.41	C	
Oct. 14	213	1.03	20.50	64.06	C	

[a] Including 13 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=65.39$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.03$. $W=213$ grams.

$M=\frac{VPS}{W}=4{,}743$ kilograms per square centimeter (67,470 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 13 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 26, 1911.	Grams.
Solid	59.2
Liquid (water)	12.1
Gaseous	127.1

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.5 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°*C.*	*Calories.*
Dec. 27	81.95	0.753	653.1
Dec. 29	81.95	.772	669.7
Do	81.95	.772	669.7

[a] Including 6.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 664.2.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Sept. 26	63.50	49.00	14.50
Do	63.50	48.75	14.75
Do	63.50	49.00	14.50

Average compression, 14.6 millimeters (0.57 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCK.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Apr. 11	63	240	177	15
Do	63	240	177	15
Do	63	246	183	15

Average expansion of bore hole, 179 cubic centimeters (10.92 cubic inches).

CARBONITE NO. 4.

Explosive, Carbonite No. 4.
Class 4, nitroglycerin.
Manufactured by the E. I. du Pont de Nemours Powder Co.
Physical examination:
  Diameter of cartridge, 1½ inches.
  Length of cartridge, 8 inches.
  Average weight, 246 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.05.
  Color of explosive, drab.
  Consistency, granular; coarse; dry; hard; slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, February 11, 1910.
Unit swing on this date, 3.26 inches.
Weight of charge, in grams, 320, 320, 320.
Swing, in inches, 3.20, 3.18, 3.20.
Average swing, in inches, 3.19.

$$3.19 : 3.26 :: 320 : (327).$$

Therefore the unit deflective charge of Carbonite No. 4 is 327 grams.

GAS AND DUST GALLERY NO. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Feb. 12	327	8.16	No ignition.
Do	327	8.16	Do.
Do	327	8.26	Do.
Do	327	8.26	Do.
Do	327	7.87	Do.
Do	327	8.21	Do.
Feb. 14	327	7.90	Do.
Do	327	8.23	Do.
Do	327	8.23	Do.
Do	327	8.13	Do.
TEST 3.			
Feb. 16	327		No ignition.
Do	327		Do.
Do	327		Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Feb. 16	327		No ignition.
Do	327		Do.
Do	327		Do.
Feb. 17	327		Do.
Do	327		Do.
Do	327		Do.
Do	327		Do.
TEST 4.			
Feb. 28	[a] 680	4.15	No ignition.
Do	[a] 680	3.97	Do.
Do	[a] 680	4.10	Do.
Do	[a] 680	4.10	Do.
Do	[a] 680	4.10	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Feb. 9	18.33	43.0	2,346
Feb. 15	18.31	43.0	2,348
Mar. 2	18.50	43.0	2,324

Average rate of detonation, 2,339 meters (7,670 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Jan. 29	7.00	8.84	2.50	0.125
Do	7.25	9.16	2.00	.100
Do	4.00	5.05	1.50	.075

Average height of flame, 7.68 inches.
Average duration of flame 0.100 millisecond.

IMPACT TEST.

Date, December 5, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
8	1	No explosion.	9	3	No explosion.
16	1	Explosion.	9	1	Explosion.
12	1	Do.	8	1	Do.
10	1	No explosion.	7	1	No explosion.
11	1	Explosion.	7	1	Explosion.
10	1	Do.	6	5	No explosion.

The maximum height at which no explosion occurs established at 6 centimeters (2.36 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 169 grams.

Date (1910).	Distance separating cartridges.	Result, upper cartridge.	Date (1910).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Dec. 5	8	Exploded.	Dec. 8	9	Did not explode.
Do	12	Did not explode.	Do	9	Do.
Dec. 8	10	Do.	Do	9	Do.

The minimum distance at which no explosion occurs established at 9 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

Date (1910).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Oct. 17	210	1.05	23.25	58.12	A	57.29
Do	210	1.05	22.50	56.25	A	
Do	210	1.05	23.00	57.50	A	
Oct. 18	210	1.05	22.50	56.25	B	55.00
Do	210	1.05	22.00	55.00	B	
Do	210	1.05	21.50	53.75	B	
Do	210	1.05	20.50	51.25	C	52.08
Oct. 19	210	1.05	20.50	51.25	C	
Do	210	1.05	21.50	53.75	C	

[a] Including 10 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=63.50$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=1.05$. $W=210$ grams.

$M=\frac{VPS}{W}=4,762$ kilograms per square centimeter (67,740 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 13 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, September 6, 1910.

	Grams.
Solid	76.2
Liquid (water)	20.0
Gaseous	113.7

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.5 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°*C.*	*Calories.*
Jan. 13	81.95	0.695	602.1
Jan. 14	81.95	.706	611.7
Do	81.95	.695	602.1

[a] Including 6.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 605.3.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1913).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Jan. 27	63.75	55.50	8.25
Do	63.50	55.00	8.50
Do	63.00	54.75	8.25

Average compression, 8.3 millimeters (0.33 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Nov. 15	63	170	107	15
Do	63	175	112	15
Do	63	170	107	15

Average expansion of bore hole, 109 cubic centimeters (6.65 inches).

CARBONITE NO. 5.

Explosive, Carbonite No. 5.
Class 4, nitroglycerin.
Manufactured by the E. I. du Pont de Nemours Powder Co.
Physical examination:
  Diameter of cartridge, ⅞ inch.
  Length of cartridge, 8 inches.
  Average weight, 86 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.06.
  Color of explosive, buff.
  Consistency, fibrous, fine, very dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, January 23, 1911.

Unit swing on this date, 3.05 inches.

Weight of charge, in grams, 320, 320, 320.

Swing, in inches, 3.26, 3.20, 3.18.

Average swing, in inches, 3.21.

$$3.21 : 3.05 :: 320 : (304).$$

Therefore the unit deflective charge of Carbonite No. 5 is 304 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Jan. 25	304	7.85	No ignition.
Do	304	7.93	Do.
Do	304	7.77	Do.
Do	304	8.13	Do.
Do	304	7.79	Do.
Do	304	8.22	Do.
Do	304	8.13	Do.
Do	304	8.14	Do.
Do	304	8.13	Do.
Do	304	8.08	Do.
TEST 3.			
Feb. 2	304		No ignition.
Do	304		Do.
Do	304		Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Feb. 2	304		No ignition.
Do	304		Do.
Do	304		Do.
Do	304		Do.
Do	304		Do.
Do	304		Do.
Do	304		Do.
TEST 4.			
Jan. 30	[a] 680	4.04	No ignition.
Do	[a] 680	3.94	Do.
Do	[a] 680	3.92	Do.
Do	[a] 680	4.13	Do.
Do	[a] 680	4.06	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.

Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Jan. 31	14.16	45.0	3,178
Do	14.82	45.0	3,038
Do	14.70	45.0	3,061

Average rate of detonation, 3,092 meters (10,140 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters*	*Milliseconds.*
July 27	13.00	16.42	6.50	0.325
Do	13.00	16.42	5.75	.288
Do	9.75	12.32	5.00	.250

Average height of flame, 15.05 inches.

Average duration of flame, 0.288 millisecond.

IMPACT TEST.

Date, July 26, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	14	1	No explosion.
14	1	No explosion.	14	1	Explosion.
17	1	Explosion.	13	1	Do.
16	1	Do.	12	1	Do.
15	1	Do.	11	5	No explosion.

The maximum height at which no explosion occurs established at 11 centimeters (4.33 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 180.5 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Sept. 21	8	Did not explode.	Sept. 21	4	Exploded.
Do	5	Do.	Do	5	Did not explode.
Do	3	Exploded.	Do	5	Do.

The minimum distance at which no explosion occurs established at 5 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
July 25	221	1.06	25.50	63.75	A	65.00
Do	221	1.06	26.00	65.00	A	
Do	221	1.06	26.50	66.25	A	
July 24	221	1.06	25.25	63.13	B	62.92
Do	221	1.06	25.25	63.13	B	
Do	221	1.06	25.00	62.50	B	
Do	221	1.06	25.00	62.50	C	61.67
Do	221	1.06	25.00	62.50	C	
Do	221	1.06	24.00	60.00	C	

[a] Including 21 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=68.66$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.06.$ $W=221$ grams.

$M=\frac{VPS}{W}=4{,}940$ kilograms per square centimeter (70,270 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 21 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 15, 1911.

	Grams.
Solid	64.1
Liquid (water)	9.3
Gaseous	139.8

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 110.5 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*°C.*	*Calories.*
July 24	80.95	0.685	565.6
July 26	80.95	.720	594.9
Do	80.95	.720	594.9

[a] Including 10.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 585.1.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Aug. 31	63.50	51.75	11.75
Do	63.50	52.25	11.25
Do	63.50	51.50	12.00

Average compression, 11.7 millimeters (0.46 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Apr. 7	63	217	154	15
Do	63	222	159	15
Do	63	218	155	15

Average expansion of bore hole, 156 cubic centimeters (9.52 cubic inches).

CARBONITE NO. 6.

Explosive, Carbonite No. 6.
Class 4, nitroglycerin.
Manufactured by the E. I. du Pont de Nemours Powder Co.
Physical examination:
  Diameter of cartridge, 7/8 inch.
  Length of cartridge, 8 inches.
  Average weight, 86 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.05.
  Color of explosive, corn.
  Consistency, granular, fine, very dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date January 23, 1911.
Unit swing on this date, 3.05 inches.
Weight of charge, in grams, 340, 340, 340.
Swing, in inches, 3.06, 2.95, 3.03.
Average swing, in inches, 3.01.

3.01 : 3.05 : : 340 : (345).

Therefore the unit deflective charge of Carbonite No. 6 is 345 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Jan. 25	345	8.23	No ignition.
Jan. 26	345	7.91	Do.
Do	345	7.93	Do.
Do	345	7.84	Do.
Do	345	8.19	Do.
Do	345	7.98	Do.
Do	345	7.90	Do.
Do	345	8.06	Do.
Do	345	8.03	Do.
Do	345	7.99	Do.
TEST 3.			
Feb. 3	345	....	No ignition.
Do	345	....	Do.
Do	345	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Feb. 3	345	....	No ignition.
Do	345	....	Do.
Do	345	....	Do.
Do	345	....	Do.
Do	345	....	Do.
Do	345	....	Do.
Do	345	....	Do.
TEST 4.			
Jan. 30	[a]680	3.99	No ignition.
Jan. 31	[a]680	3.94	Do.
Do	[a]680	4.02	Do.
Do	[a]680	4.02	Do.
Do	[a]680	4.12	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Jan. 31	19.55	45.0	2,302
Do	19.38	45.0	2,322
Feb. 10	20.18	45.0	2,230

Average rate of detonation, 2,285 meters (7,490 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
July 27	9.75	12.32	4.50	0.225
Do	11.50	14.53	7.00	.350
Do	11.25	14.21	6.00	.300

Average height of flame, 13.69 inches.
Average duration of flame, 0.292 millisecond.

IMPACT TEST.

Date, July 26, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
15	1	No explosion.	15	1	Explosion.
20	1	Explosion.	14	1	Do.
17	1	Do.	13	1	Do.
16	1	Do.	12	5	No explosion.

The maximum height at which no explosion occurs established at 12 centimeters (4.72 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 179 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Sept. 22	7	Did not explode.	Sept. 22	3	Exploded.
Do	4	Do.	Do	4	Did not explode.
Do	3	Do.	Do	4	Do.
Do	2	Exploded.			

The minimum distance at which no explosion occurs established at 4 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
July 26	221	1.05	22.00	55.00	A	55.42
Do	221	1.05	21.75	54.38	A	
Do	221	1.05	22.75	56.88	A	
July 25	221	1.05	21.50	53.75	B	53.13
Do	221	1.05	20.75	51.88	B	
Do	221	1.05	21.50	53.75	B	
Do	221	1.05	20.25	50.63	C	50.21
Do	221	1.05	20.00	50.00	C	
Do	221	1.05	20.00	50.00	C	

[a] Including 21 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=61.63$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.05$. $W=221$ grams.

$M=\frac{VPS}{W}=4{,}392$ kilograms per square centimeter (62,470 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 21 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 16, 1911.

	Grams.
Solid	71.7
Liquid (water)	11.8
Gaseous	123.8

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 110.5 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*°C.*	*Calories.*
July 27	80.95	0.678	559.8
Do	80.95	.706	583.2
Do	80.95	.697	575.6

[a] Including 10.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 572.9.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Aug. 31	63.25	54.25	9.00
Do	63.50	54.75	8.75
Do	63.50	54.75	8.75

Average compression, 8.8 millimeters (0.35 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Apr. 7	63	183	120	15
Do	63	181	118	15
Do	63	188	125	15

Average expansion of bore hole, 121 cubic centimeters (7.38 cubic inches).

COALITE A.

Explosive, Coalite A.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Potts Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 171 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 0.98.
  Color of explosive, ecru.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by ballistic pendulum:

Date, January 10, 1912.
Unit swing on this date, 3.40 inches.
Weight of charge, in grams, 245, 245, 245.
Swing, in inches, 3.36, 3.38, 3.44.
Average swing, in inches, 3.39.

3.39 : 3.40 : : 245 : (246).

Therefore the unit deflective charge of Coalite A is 246 grams.

GAS AND DUST GALLERY NO. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Jan. 15	246	8.24	No ignition.
Do	246	8.41	Do.
Do	246	8.09	Do.
Do	246	7.85	Do.
Jan. 16	246	7.98	Do.
Do	246	7.92	Do.
Do	246	7.88	Do.
Do	246	8.32	Do.
Do	246	8.04	Do.
Do	246	8.16	Do.
TEST 3.			
Jan. 23	246	....	No ignition.
Do	246	....	Do.
Do	246	....	Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Jan. 23	246	....	No ignition.
Do	246	....	Do.
Do	246	....	Do.
Do	246	....	Do.
Do	246	....	Do.
Do	246	....	Do.
Do	246	....	Do.
TEST 4.			
Jan. 19	[a] 680	4.07	No ignition.
Jan. 20	[a] 680	3.91	Do.
Do	[a] 680	3.94	Do.
Jan. 22	[a] 680	4.06	Do.
Do	[a] 680	4.02	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Jan. 12	16.60	44.5	2.681
Do	16.50	44.0	2.666
Do	16.25	45.0	2,769

Average rate of detonation, 2,705 meters (8,870 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 8	14.00	17.68	5.00	0.250
Do	13.75	17.37	5.50	.275
Do	15.25	19.26	5.00	.250

Average height of flame, 18.10 inches.
Average duration of flame, 0.258 millisecond.

IMPACT TEST.

Date, March 4, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	16	4	No explosion.
19	1	Do.	16	1	Explosion.
18	2	No explosion.	15	1	No explosion.
18	1	Explosion.	15	1	Explosion.
17	4	No explosion.	14	5	No explosion.
17	1	Explosion.			

The maximum height at which no explosion occurs established at 14 centimeters (5.51 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 158 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Apr. 12	3	Exploded.	Apr. 12	9	Exploded.
Do	4	Do.	Do	12	Did not explode.
Do	5	Do.	Do	10	Do.
Do	6	Do.	Do	10	Do.
Do	7	Do.	Do	10	Do.

The minimum distance at which no explosion occurs established at 10 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Apr. 11	219	0.98	31.25	97.66	A	98.70
Do	219	.98	31.75	99.22	A	
Do	219	.98	31.75	99.22	A	
Do	219	.98	28.75	89.84	B	90.36
Do	219	.98	29.00	90.62	B	
Do	219	.98	29.00	90.62	B	
Do	219	.98	28.00	87.50	C	89.06
Do	219	.98	28.50	89.06	C	
Do	219	.98	29.00	90.62	C	

[a] Including 19 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=108.13$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=0.98$ $W=219$ grams.

$M=\frac{VPS}{W}=7{,}258$ kilograms per square centimeter (103,230 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 19 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst A. L. Hyde.]

Date, February 1, 1912.	Grams.
Solid	10.5
Liquid (water)	77.0
Gaseous	120.6

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 109.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°*C.*	*Calories.*
Mar. 7	81.95	0.700	589.9
Do	81.95	.719	606.1
Do	81.95	.690	581.4

[a] Including 9.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 592.5.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Apr. 9	63.25	50.50	12.75
Do	63.25	51.00	12.25
Do	63.50	51.00	12.50

Average compression, 12.5 millimeters (0.49 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Apr. 11	63	267	204	15
Do	63	270	207	15
Do	63	265	202	15

Average expansion of bore hole, 204 cubic centimeters (12.44 cubic inches).

COALITE X.

Explosive, Coalite X.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Potts Powder Co.
Physical examination:
- Diameter of cartridge, 1¼ inches.
- Length of cartridge, 8 inches.
- Average weight, 174 grams.
- Cartridge had been redipped.
- Apparent specific gravity of cartridge by sand, 0.92.
- Color of explosive, ecru.
- Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by ballistic pendulum:

Date, January 10, 1912.
Unit swing on this date, 3.40 inches.
Weight of charge, in grams, 225, 225, 225.
Swing, in inches, 3.43, 3.42, 3.33.
Average swing, in inches, 3.39.

3.39 : 3.40 : : 225 : (226).

Therefore the unit deflective charge of Coalite X is 226 grams.

GAS AND DUST GALLERY No. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Jan. 11	226	8.42	No ignition.
Do	226	8.21	Do.
Jan. 12	226	7.93	Do.
Do	226	7.87	Do.
Do	226	8.20	Do.
Do	226	7.80	Do.
Do	226	7.79	Do.
Do	226	7.76	Do.
Do	226	7.91	Do.
Do	226	7.89	Do.
TEST 3.			
Jan. 22	226		No ignition.
Do	226		Do.
Do	226		Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Jan. 22	226		No ignition.
Do	226		Do.
Do	226		Do.
Do	226		Do.
Jan. 23	226		Do.
Do	226		Do.
Do	226		Do.
TEST 4.			
Jan. 19	[a] 680	4.26	No ignition.
Do	[a] 680	4.05	Do.
Do	[a] 680	3.92	Do.
Do	[a] 680	3.92	Do.
Do	[a] 680	4.13	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Jan. 12	16.55	44.5	2,689
Do	15.90	44.5	2,799
Do	16.20	44.5	2,748

Average rate of detonation, 2,745 meters (9,000 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 8	14.50	18.32	7.75	0.388
Do	15.00	18.95	5.25	.262
Do	14.00	17.68	7.00	.350

Average height of flame, 18.32 inches.
Average duration of flame, 0.333 millisecond.

IMPACT TEST.

Date, March 2, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
15	3	No explosion.	25	1	Explosion.
18	2	Do.	20	1	Do.
20	2	Do.	18	1	Do.
25	1	Do.	16	1	No explosion.
30	1	Explosion.	17	5	Do.

The maximum height at which no explosion occurs established at 17 centimeters (6.69 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 146 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Apr. 13	6	Exploded.	Apr. 13	7	Did not explode.
Do	8	Did not explode.	Do	7	Do.
Do	7	Do.			

The minimum distance at which no explosion occurs established at 7 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Apr. 10	219	0.92	30.00	93.75	A	94.01
Do	219	.92	30.00	93.75	A	
Do	219	.92	30.25	94.53	A	
Do	219	.92	27.00	84.38	B	85.42
Do	219	.92	27.50	85.94	B	
Do	219	.92	27.50	85.94	B	
Do	219	.92	26.00	81.25	C	81.51
Do	219	.92	26.00	81.25	C	
Apr. 11	219	.92	26.25	82.03	C	

[a] Including 19 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=107.35$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=0.92$. $W=219.0$ grams.

$M=\frac{VPS}{W}=6,765$ kilograms per square centimeter (96,220 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 18 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, January 31, 1912.	Grams.
Solid	6.5
Liquid (water)	71.0
Gaseous	132.6

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 109.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°*C.*	*Calories.*
Mar. 6	81.95	1.126	953.6
Do	81.95	1.170	991.2
Do	81.95	1.126	953.6

[a] Including 9.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 966.1.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Apr. 9	63.25	49.25	14.00
Do	63.25	49.50	13.75
Do	63.25	49.25	14.00

Average compression, 13.9 millimeters (0.55 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Apr. 10	63	326	263	15
Do	63	319	256	15
Do	63	318	255	15

Average expansion of bore hole, 258 cubic centimeters (15.74 cubic inches).

COALITE NO. 2–D. L.

Explosive, Coalite No. 2–D. L.

Class 4, nitroglycerin.

Manufactured by the Potts Powder Co.

Physical examination:

Diameter of cartridge, 1¼ inches.

Length of cartridge, 8 inches.

Average weight, 154 grams.

Cartridge had been redipped.

Apparent specific gravity of cartridge by sand, 0.89.

Color of explosive, corn.

Consistency, fibrous, fine, dry, very soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, October 28, 1910.

Unit swing on this date, 3.15 inches.

Weight of charge, in grams, 287, 287, 287.

Swing, in inches, 3.40, 3.33, 3.30.

Average swing, in inches, 3.34.

3.34 : 3.15 : : 2.87 : (271).

Therefore the unit deflective charge of Coalite No. 2–D. L. is 271 grams.

GAS AND DUST GALLERY NO. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Oct. 31	271	7.75	No ignition.
Do	271	7.90	Do.
Do	271	8.28	Do.
Do	271	8.04	Do.
Do	271	7.84	Do.
Do	271	7.97	Do.
Nov. 1	271	8.06	Do.
Do	271	7.85	Do.
Do	271	7.80	Do.
Do	271	7.87	Do.
TEST 3.			
Nov. 1	271		No ignition.
Do	271		Do.
Do	271		Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Nov. 1	271		No ignition.
Do	271		Do.
Do	271		Do.
Do	271		Do.
Do	271		Do.
Do	271		Do.
Do	271		Do.
TEST 4.			
Nov. 2	[a]680	3.97	No ignition.
Do	[a]680	3.99	Do.
Do	[a]680	4.05	Do.
Do	[a]680	4.07	Do.
Do	[a]680	4.20	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.

Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
June 13	19.95	44.0	2,206
Do	19.70	43.5	2,208
Do	19.15	44.0	2,298

Average rate of detonation, 2,237 meters (7,340 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
June 7	9.25	11.68	4.50	0.225
Do	8.25	10.42	4.25	.213
Do	11.50	14.53	6.00	.300

Average height of flame, 12.21 inches.

Average duration of flame, 0.246 millisecond.

IMPACT TEST.

Date, June 7, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	15	1	Explosion.
10	1	No explosion.	14	1	Do.
16	1	Do.	13	2	No explosion.
18	1	Explosion.	13	1	Explosion.
17	1	Do.	12	1	Do.
16	1	Do.	11	5	No explosion.

The maximum height at which no explosion occurs established at 11 centimeters (4.33 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 143 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
May 29	8	Did not explode.	May 29	3	Exploded.
Do	6	Do.	June 1	4	Did not explode.
Do	2	Exploded.	Do	4	Do.
Do	4	Did not explode.			

The minimum distance at which no explosion occurs established at 4 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
May 29	220	0.89	21.75	67.97	A	66.67
Do	220	.89	20.75	64.84	A	
Do	220	.89	21.50	67.19	A	
Do	220	.89	[b] 24.50	61.25	B	62.09
Do	220	.89	[b] 25.25	63.13	B	
Do	220	.89	[b] 24.75	61.88	B	
May 31	220	.89	[b] 24.50	61.25	C	60.63
Do	220	.89	[b] 23.75	59.38	C	
Do	220	.89	[b] 24.50	61.25	C	

[a] Including 20 grams of the original wrapper.
[b] Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

$P=1.911A+0.5B-1.411C=72.90$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=0.89$. $W=220$ grams.

$M=\frac{VPS}{W}=4,424$ kilograms per square centimeter (62,930 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 20 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 5, 1911.

	Grams.
Solid	80.5
Liquid (water)	9.7
Gaseous	124.6

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 110.0 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	° C.	*Calories.*
May 31	80.95	0.701	581.6
Do	80.95	.698	579.1
Do	80.95	.701	581.6

[a] Including 10 grams of the original wrapper.

Average large calories per kilogram of explosive, 580.8.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
June 15	63.25	56.75	6.50
Do	63.00	56.75	6.25
Do	63.25	56.75	6.50

Average compression, 6.4 millimeters (0.25 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	° *C.*
Mar. 25	63	224	161	15
Do	63	220	157	15
Do	63	220	157	15

Average expansion of bore hole, 158 cubic centimeters (9.64 cubic inches).

COALITE NO. 2–M, L. F.

Explosive, Coalite No. 2–M, L. F.

Class 4, nitroglycerin.

Manufactured by the Potts Powder Co.

Physical examination:

Diameter of cartridge, 1¼ inches.

Length of cartridge, 8 inches.

Average weight, 174.5 grams.

Cartridge had not been redipped.

Apparent specific gravity by sand, 1.01.

Color of explosive, corn.

Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by ballistic pendulum:

Date, January 10, 1912.
Unit swing on this date, 3.40 inches.
Weight of charge, in grams, 310, 310, 310.
Swing, in inches, 3.42, 3.55, 3.53.
Average swing, in inches, 3.50.

3.50 : 3.40 : : 310 : (301).

Therefore the unit deflective charge of Coalite No. 2–M, L. F., is 301 grams.

GAS AND DUST GALLERY NO. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Jan. 16	301	8.31	No ignition.
Do	301	8.50	Do.
Do	301	8.33	Do.
Jan. 17	301	8.38	Do.
Do	301	8.29	Do.
Do	301	8.23	Do.
Do	301	8.34	Do.
Do	301	8.12	Do.
Do	301	8.16	Do.
Do	301	8.34	Do.
TEST 3.			
Jan. 24	301		No ignition.
Do	301		Do.
Do	301		Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Jan. 24	301		No ignition.
Do	301		Do.
Do	301		Do.
Do	301		Do.
Do	301		Do.
Do	301		Do.
Do	301		Do.
TEST 4.			
Jan. 18	[a] 680	4.09	No ignition.
Do	[a] 680	4.14	Do.
Do	[a] 680	3.99	Do.
Do	[a] 680	4.04	Do.
Do	[a] 680	4.03	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Jan. 11	16.05	44.5	2,773
Do	15.70	45.0	2,866
Do	16.10	45.0	2,795

Average rate of detonation, 2,811 meters (9,220 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 6	14.00	17.68	7.25	0.362
Do	15.75	19.89	7.00	.350
Do	14.75	18.63	7.50	.375

Average height of flame, 18.73 inches.
Average duration of flame, 0.362 millisecond.

IMPACT TEST.

Date, February 27, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
15	1	No explosion.	19	1	Explosion.
20	1	Do.	18	1	No explosion.
25	1	Explosion.	18	1	Explosion.
23	1	No explosion.	17	3	No explosion.
23	1	Explosion.	17	1	Explosion.
22	1	Do.	16	1	Do.
21	1	Do.	15	2	No explosion.
20	1	Do.	15	1	Explosion.
19	2	No explosion.	14	5	No explosion.

The maximum height at which no explosion occurs established at 14 centimeters (5.51 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 162 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Apr. 4	3	Did not explode.	Apr. 5	3	Exploded.
Do	2	Do.	Do	4	Do.
Do	1	Exploded.	Do	5	Did not explode.
Do	2	Do.	Do	5	Do.
Apr. 5	3	Did not explode.	Do	5	Do.

The minimum distance at which no explosion occurs established at 5 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Apr. 8	215	1.01	20.25	63.28	A	64.32
Do	215	1.01	21.00	65.62	A	
Do	215	1.01	20.50	64.06	A	
Do	215	1.01	20.00	62.50	B	62.24
Do	215	1.01	19.75	61.72	B	
Do	215	1.01	20.00	62.50	B	
Apr. 9	215	1.01	19.00	59.38	C	60.68
Do	215	1.01	19.50	60.94	C	
Do	215	1.01	19.75	61.72	C	

[a] Including 15 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=68.42$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.01$. $W=215$ grams.

$M=\frac{VPS}{W}=4{,}821$ kilograms per square centimeter (68,570 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 15 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, January 12, 1912.

	Grams.
Solid	70.1
Liquid (water)	4.6
Gaseous	124.4

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Mar. 2	81.95	0.704	604.3
Do	81.95	.730	626.9
Do	81.95	.711	610.4

[a] Including 7.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 613.9.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Apr. 9	63.25	50.50	12.75
Do	63.25	50.75	12.50
Apr. 10	63.25	51.00	12.25

Average compression, 12.5 millimeters (0.49 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Apr. 10	63	226	163	15
Do	63	219	156	15
Do	63	223	160	15

Average expanison of bore hole, 160 cubic centimeters (9.76 cubic inches).

COALITE NO. 3-X.

Explosive, Coalite No. 3-X.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Potts Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 187 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 1.08.
  Color of explosive, corn.
  Consistency, granular, coarse, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, October 28, 1910.

Unit swing on this date, 3.15 inches.

Weight of charge, in grams, 267, 267, 267.

Swing, in inches, 3.07, 3.04, 3.09.

Average swing, in inches, 3.07.

3.07 : 3.15 : : 267 : (274).

Therefore the unit deflective charge of Coalite No. 3–X is 274 grams.

GAS AND DUST GALLERY NO. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Oct. 31	274	8.15	No ignition.
Do	274	7.94	Do.
Nov. 1	274	8.12	Do.
Do	274	8.12	Do.
Do	274	7.88	Do.
Do	274	8.00	Do.
Do	274	8.03	Do.
Do	274	8.08	Do.
Do	274	8.02	Do.
Do	274	7.76	Do.
TEST 3.			
Nov. 1	274	....	No ignition.
Do	274	....	Do.
Do	274	....	Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Nov. 2	274	....	No ignition.
Do	274	....	Do.
Do	274	....	Do.
Do	274	....	Do.
Do	274	....	Do.
Do	274	....	Do.
Do	274	....	Do.
TEST 4.			
Nov. 2	[a] 680	3.95	No ignition.
Do	[a] 680	4.05	Do.
Do	[a] 680	4.04	Do.
Do	[a] 680	4.15	Do.
Do	[a] 680	3.91	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.

Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Nov. 17	19.29	43.5	2,255
Do	19.80	43.0	2,172
Do	19.40	43.5	2,242

Average rate of detonation, 2,223 meters (7,290 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Feb. 19	5.25	6.63	1.50	0.075
Do	5.00	6.32	1.25	.062
Do	3.50	4.42	1.00	.050

Average height of flame, 5.79 inches.

Average duration of flame, 0.062 millisecond.

IMPACT TEST.

Date, June 8, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	15	1	Explosion.
16	1	Do.	14	1	Do.
14	1	No explosion.	13	5	No explosion.

The maximum height at which no explosion occurs established at 13 centimeters (5.12 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 174 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
June 1	6	Did not explode.	June 1	2	Exploded.
Do	4	Do.	Do	3	Did not explode.
Do	2	Do.	Do	3	Do.
Do	1	Exploded.	Do	3	Do.

The minimum distance at which no explosion occurs established at 3 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
June 3	220	1.10	25.50	79.69	A	80.47
Do	220	1.10	26.00	81.25	A	
Do	220	1.10	25.75	80.47	A	
June 2	220	1.10	24.25	75.78	B	76.03
Do	220	1.10	24.00	75.00	B	
Do	220	1.10	24.75	77.32	B	
May 31	220	1.10	23.00	71.87	C	72.92
Do	220	1.10	23.50	73.44	C	
Do	220	1.10	23.50	73.44	C	

[a] Including 20 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=88.91$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.08$. $W=220$ grams.

$M=\frac{VPS}{W}=6{,}547$ kilograms per square centimeter (93,130 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 20 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 6, 1911.	Grams.
Solid	44.2
Liquid (water)	63.0
Gaseous	115.2

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 110.0 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*°C.*	*Calories.*
May 31	80.95	0.902	750.6
June 1	80.95	.910	757.4
Do	80.95	.896	745.6

[a] Including 10 grams of the original wrapper.

Average large calories per kilogram of explosive, 751.2.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
May 22	63.50	51.25	12.25
Do	63.50	51.50	12.00
Do	63.50	51.50	12.00

Average compression, 12.1 millimeters (0.48 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Mar. 25	63	268	205	15
Do	63	270	207	15
Do	63	275	212	15

Average expansion of bore hole, 208 cubic centimeters (12.69 cubic inches).

COALITE NO. 3–XA.

Explosive, Coalite No. 3–XA.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Potts Powder Co.
Physical examination:
  Diameter of cartridge, 1⅛ inches.
  Length of cartridge, 8 inches.
  Average weight, 128 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 0.93.
  Color of explosive, corn.
  Consistency, granular with white crystals, very fine, dry, very soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, April 10, 1911.
Unit swing on this date, 2.93 inches.
Weight of charge, in grams, 274, 274, 274.
Swing, in inches, 2.78, 2.78, 2.67.
Average swing, in inches, 2.74.

2.74 : 2.93 : : 274 : (293).

Therefore the unit deflective charge of Coalite No. 3-XA is 293 grams.

Gas and Dust Gallery No. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.	Date (1911).	Weight of charge.	Methane and ethane.	Result.
Test 1.				Test 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Apr. 14	293	8.27	No ignition.	Apr. 19	293	....	No ignition.
Do	293	8.09	Do.	Do	293	....	Do.
Do	293	8.07	Do.	Do	293	....	Do.
Apr. 15	293	8.07	Do.	Apr. 20	293	....	Do.
Do	293	8.08	Do.	Do	293	....	Do.
Do	293	8.10	Do.	Do	293	....	Do.
Do	293	8.00	Do.	Do	293	....	Do.
Do	293	8.21	Do.				
Do	293	7.94	Do.	Test 4.			
Do	293	7.97	Do.		*Grams.*	*Per cent.*	
				Apr. 21	[a] 680	3.98	No ignition.
Test 3.				Do	[a] 680	3.99	Do.
	Grams.	*Per cent.*		Do	[a] 680	3.80	Do.
Apr. 19	293	....	No ignition.	Apr. 22	[a] 680	3.96	Do.
Do	293	....	Do.	Do	[a] 680	4.07	Do.
Do	293	....	Do.				

[a] 680 grams or more was used.

Rate of Detonation.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation.
	Millimeters.	*Meters.*	*Meters.*
Apr. 17	14.16	46.00	3,249
Do	14.56	46.25	3,177
Do	14.91	46.25	3,102

Average rate of detonation, 3,176 meters (10,420 feet) per second.

Flame Test.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Jan. 3	14.50	18.32	8.00	0.400
Do	18.25	23.05	6.25	.312
Do	18.50	23.37	7.25	.362

Average height of flame, 21.58 inches.
Average duration of flame, 0.358 millisecond.

IMPACT TEST.

Date, July 25, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
16	1	Explosion.	15	5	No explosion.
14	1	No explosion.			

The maximum height at which no explosion occurs established at 15 centimeters (5.91 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 150 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Jan. 18	2	Did not explode.	Jan. 18	2	Did not explode.
Do	1	Exploded.	Do	2	Do.

The minimum distance at which no explosion occurs established at 2 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Nov. 21	221	0.93	24.75	77.34	A	76.04
Nov. 22	221	.93	24.50	76.56	A	
Do	221	.93	23.75	74.22	A	
Nov. 14	221	.93	23.25	72.66	B	74.48
Do	221	.93	24.50	76.56	B	
Do	221	.93	23.75	74.22	B	
Nov. 15	221	.93	22.50	70.31	C	70.83
Nov. 16	221	.93	22.50	70.31	C	
Do	221	.93	23.00	71.87	C	

[a] Including 21 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=82.61$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=0.93$. $W=221$ grams.

$M=\frac{VPS}{W}=5{,}215$ kilograms per square centimeter.

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 21 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, July 10, 1911.

	Grams.
Solid	10.1
Liquid (water)	63.5
Gaseous	128.2

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 110.5 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*°C.*	*Calories.*
Dec. 20	81.95	0.925	774.9
Do	81.95	.884	740.2
Do	81.95	.908	760.5

[a] Including 10.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 758.5.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Nov. 3	63.50	48.75	14.75
Do	63.50	48.50	15.00
Do	63.50	49.00	14.50

Average compression, 14.8 millimeters (0.58 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Jan. 16	62	274	212	20
Do	62	274	212	17
Do	62	272	210	18

Average expansion of bore hole, 211 cubic centimeters (12.87 cubic inches).

COALITE NO. 3-XB.

Explosive, Coalite No. 3-XB.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Potts Powder Co.
Physical examination:
    Diameter of cartridge, 1⅛ inches.
    Length of cartridge, 8 inches.
    Average weight, 128 grams.
    Cartridge had been redipped.
    Apparent specific gravity of cartridge by sand, 0.92.
    Color of explosive, drab.
    Consistency, granular and fibrous with white crystals, very fine, dry, very soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:
Date, April 10, 1911.
Unit swing on this date, 2.93 inches.
Weight of charge, in grams, 293, 293, 293.
Swing, in inches, 2.90, 2.95, 2.94.
Average swing, in inches, 2.93.

2.93 : 2.93 : : 293 : (293).

Therefore the unit deflective charge of Coalite No. 3-XB is 293 grams.

GAS AND DUST GALLERY No. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Apr. 15	293	8.05	No ignition.
Apr. 17	293	8.11	Do.
Do	293	7.85	Do.
Do	293	8.13	Do.
Do	293	8.26	Do.
Do	293	8.08	Do.
Do	293	8.04	Do.
Do	293	8.16	Do.
Do	293	7.94	Do.
Do	293	8.07	Do.
TEST 3.			
Apr. 20	293		No ignition.
Do	293		Do.
Do	293		Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Apr. 20	293		No ignition.
Do	293		Do.
Do	293		Do.
Do	293		Do.
Do	293		Do.
Do	293		Do.
Do	293		Do.
TEST 4.			
Apr. 22	[a] 680	4.00	No ignition.
May 17	[a] 680	4.08	Do.
Do	[a] 680	4.01	Do.
Do	[a] 680	4.00	Do.
Do	[a] 680	4.02	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Apr. 17	13.70	46.75	3,412
Do	13.41	46.75	3,486
Apr. 18	12.70	43.50	3,425

Average rate of detonation, 3,441 meters (11,290 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Sept. 11	5.75	7.26	1.75	0.875
Do	11.00	13.89	4.50	2.250
Do	5.75	7.26	1.25	.625

Average height of flame, 9.47 inches.
Average duration of flame, 1.25 milliseconds.

IMPACT TEST.

Date, July 25, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
16	1	No explosion.	21	1	No explosion.
18	1	Do.	21	1	Explosion.
22	1	Explosion.	20	5	No explosion.

The maximum height at which no explosion occurs established at 20 centimeters (7.87 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 148 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Jan. 18	2	Did not explode.	Jan. 18	2	Did not explode.
Do	1	Exploded.	Do	2	Do.

The minimum distance at which no explosion occurs established at 2 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Nov. 9	220	0.92	27.00	84.37	A	83.07
Nov. 10	220	.92	26.25	82.03	A	
Do	220	.92	26.50	82.81	A	
Do	220	.92	24.00	75.00	B	73.97
Do	220	.92	24.00	75.00	B	
Do	220	.92	23.00	71.90	B	
Do	220	.92	24.50	76.56	C	75.26
Do	220	.92	24.00	75.00	C	
Do	220	.92	23.75	74.23	C	

[a] Including 20 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=89.54$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=0.92$. $W=220$ grams.

$M=\frac{VPS}{W}=5,617$ kilograms per square centimeter (79,900 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 20 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, July 11, 1911.

	Grams.
Solid	18.7
Liquid (water)	62.5
Gaseous	125.1

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 110.0 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*°C.*	*Calories.*
Dec. 2	81.95	0.912	767.4
Dec. 14	81.95	.927	780.1
Dec. 27	81.95	.948	798.0

[a] Including 10 grams of the original wrapper.

Average large calories per kilogram of explosive, 781.8.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Nov. 2	63.50	49.00	14.50
Do	63.50	48.75	14.75
Do	63.50	48.50	15.00

Average compression, 14.8 millimeters (0.58 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Sept. 12	63	287	224	15
Do	63	298	235	15
Do	63	294	231	15

Average expansion of bore hole, 230 cubic centimeters (14.03 cubic inches).

COALITE NO. 3–XC.

Explosive, Coalite No. 3–XC.

Class 1*a*, ammonium nitrate, containing nitroglycerin.

Manufactured by the Potts Powder Co.

Physical examination:

- Diameter of cartridge, 1¼ inches.
- Length of cartridge, 8 inches.
- Average weight, 169 grams.
- Cartridge had been redipped.
- Apparent specific gravity of cartridge by sand, 0.93.
- Color of explosive, ecru.
- Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by ballistic pendulum:

Date, January 10, 1912.
Unit swing on this date, 3.40 inches.
Weight of charge, in grams, 255, 255, 255.
Swing, in inches, 3.50, 3.42, 3.48.
Average swing, in inches, 3.47.

3.47 : 3.40 : : 255 : (250).

Therefore the unit deflective charge of Coalite No. 3–XC is 250 grams.

Gas and Dust Gallery No. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Jan. 13	250	8.21	No ignition.
Do	250	8.22	Do.
Jan. 15	250	8.00	Do.
Do	250	8.23	Do.
Do	250	8.50	Do.
Do	250	8.25	Do.
Do	250	8.14	Do.
Do	250	7.99	Do.
Do	250	7.92	Do.
Do	250	8.11	Do.
TEST 3.			
Jan. 23	250		No ignition.
Do	250		Do.
Do	250		Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Jan. 23	250		No ignition.
Do	250		Do.
Do	250		Do.
Do	250		Do.
Jan. 24	250		Do.
Do	250		Do.
Do	250		Do.
TEST 4.			
Jan. 18	[a]680	4.20	No ignition.
Do	[a]680	4.14	Do.
Do	[a]680	4.07	Do.
Do	[a]680	4.03	Do.
Do	[a]680	4.00	Do.

[a] 680 grams or more was used.

Rate of Detonation.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Jan. 11	17.40	44.5	2,557
Do	17.60	44.0	2,500
Jan. 12	17.65	45.0	2,550

Average rate of detonation, 2,536 meters (8,320 feet) per second.

Flame Test.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 8	13.50	17.05	5.00	0.250
Do	13.75	17.37	6.00	.300
Do	13.50	17.05	7.25	.362

Average height of flame, 17.16 inches.
Average duration of flame, 0.304 millisecond.

IMPACT TEST.

Date, February 27, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
15	1	No explosion.	13	5	No explosion.
15	1	Explosion.	14	5	Do.

The maximum height at which no explosion occurs established at 14 centimeters (5.51 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 150 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Apr. 17	6	Did not explode.	Apr. 17	2	Did not explode.
Do	5	Do.	Do	2	Do.
Do	4	Do.	Do	1	Exploded.
Do	3	Do.	Do	2	Did not explode.

The minimum distance at which no explosion occurs established at 2 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Apr. 10	221	0.93	27.25	85.16	A	85.16
Do	221	.93	27.25	85.16	A	
Do	221	.93	27.25	85.16	A	
Apr. 9	221	.93	25.50	79.69	B	80.99
Do	221	.93	26.50	82.81	B	
Do	221	.93	25.75	80.47	B	
Do	221	.93	27.00	84.38	C	85.16
Do	221	.93	27.75	86.72	C	
Do	221	.93	27.00	84.38	C	

[a] Including 21 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=83.08$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=0.93$. $W=221.0$ grams.

$M=\frac{VPS}{W}=5,244$ kilograms per square centimeter (74,590 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 21 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, January 31, 1912.	Grams.
Solid	10.8
Liquid (water)	69.0
Gaseous	129.8

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 110.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*°C.*	*Calories.*
Mar. 5	81.95	1.296	1,088.9
Do	81.95	1.316	1,105.8
Mar. 6	81.95	1.346	1,131.1

[a] Including 10.5 grams of the original wrapper.

Average large calories per kilogram of the explosive, 1,108.6.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Apr. 9	63.50	51.25	12.25
Do	63.50	51.00	12.50
Do	63.25	50.75	12.50

Average compression, 12.4 millimeters (0.49 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Apr. 10	63	317	254	15
Do	63	310	247	15
Do	63	309	246	15

Average expansion of bore hole, 249 cubic centimeters (15.19 cubic inches).

COAL SPECIAL NO. 2-W.

Explosive, Coal special No. 2-W.
Class 4, nitroglycerin.
Manufactured by the Keystone National Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8⅛ inches.
  Average weight, 179 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.08.
  Color of explosive, corn.
  Consistency, fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, October 13, 1910.
Unit swing on this date, 3.28 inches.
Weight of charge, in grams, 290, 290, 290.
Swing, in inches, 3.35, 3.45, 3.52.
Average swing, in inches, 3.44.

3.44 : 3.28 : : 290 : (277).

Therefore the unit deflective charge of Coal special No. 2-W is 277 grams.

GAS AND DUST GALLERY NO. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.	Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Oct. 13	277	7.83	No ignition.	Oct. 18	277	....	No ignition.
Do	277	7.80	Do.	Do	277	....	Do.
Do	277	7.81	Do.	Do	277	....	Do.
Oct. 14	277	7.95	Do.	Do	277	....	Do.
Do	277	7.94	Do.	Do	277	....	Do.
Do	277	8.04	Do.	Do	277	....	Do.
Do	277	7.80	Do.	Do	277	....	Do.
Do	277	7.92	Do.				
Do	277	7.92	Do.	TEST 4.			
Do	277	7.92	Do.				
				Oct. 20	[a]680	3.96	No ignition.
TEST 3.				Do	[a]680	3.95	Do.
				Do	[a]680	4.15	Do.
Oct. 18	277	....	No ignition.	Do	[a]680	4.04	Do.
Do	277	....	Do.	Do	[a]680	4.13	Do.
Do	277	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Oct. 20	12.40	43.5	3,508
Oct. 26	12.30	43.5	3,537
Do	12.23	43.5	3,557

Average rate of detonation, 3,534 meters (11,590 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
June 6	14.25	18.00	5.75	0.288
Do	16.00	20.21	6.00	.300
Do	13.00	16.42	5.75	.288

Average height of flame, 18.21 inches.
Average duration of flame, 0.292 millisecond.

IMPACT TEST.

Date, May 19, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	10	1	No explosion.
12	1	Do.	11	5	Do.
8	1	No explosion.			

The maximum height at which no explosion occurs established at 11 centimeters (4.33 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 174 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
May 13	8	Did not explode.	May 15	7	Exploded.
Do	6	Do.	Do	8	Did not explode.
Do	4	Exploded.	Do	8	Exploded.
May 15	5	Do.	Do	9	Did not explode.
Do	6	Do.	Do	9	Do.
Do	7	Did not explode.	Do	9	Do.

The minimum distance at which no explosion occurs established at 9 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
May 10	214	1.08	25.50	63.75	A	64.17
Do	214	1.08	25.75	64.38	A	
Do	214	1.08	25.75	64.38	A	
May 11	214	1.08	23.50	58.75	B	59.38
Do	214	1.08	24.00	60.00	B	
Do	214	1.08	23.75	59.38	B	
Do	214	1.08	24.00	60.00	C	60.00
Do	214	1.08	23.75	59.38	C	
Do	214	1.08	24.25	60.62	C	

[a] Including 14 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=67.66$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.08$. $W=214$ grams.

$M=\frac{VPS}{W}=5{,}122$ kilograms per square centimeter (72,860 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 14 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, May 24, 1911.	Grams.
Solid	69.0
Liquid (water)	9.4
Gaseous	121.8

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.0 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
May 24	80.95	0.811	693.1
May 25	80.95	.806	688.8
Do	80.95	.807	689.0

[a] Including 7 grams of the original wrapper.

Average large calories per kilogram of explosive, 690.5.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
May 20	63.50	47.75	15.75
Do	63.50	47.75	15.75
Do	63.50	47.75	15.75

Average compression, 15.8 millimeters (0.62 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Mar. 23	63	220	157	15
Do	63	218	155	15
Do	63	220	157	15

Average expansion of bore hole, 156 cubic centimeters (9.52 cubic inches).

COAL SPECIAL NO. 3–C.

Explosive, Coal special No. 3–C.

Class 4, Nitroglycerin.

Manufactured by the Keystone National Powder Co.

Physical examination:

Diameter of cartridge, 1¼ inches.

Length of cartridge, 8 inches.

Average weight, 185 grams.

Cartridge had not been redipped.

Apparent specific gravity of cartridge by sand, 1.12.

Color of explosive, straw.

Consistency, granular and fibrous, fine, dry, soft, moderately cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, November 3, 1909.

Unit swing on this date, 3.06 inches.

Weight of charge, in grams, 300, 300, 300.

Swing, in inches, 3.19, 3.17, 3.22.

Average swing, in inches, 3.19.

3.19 : 3.06 : : 300 : (288).

Therefore the unit deflective charge of Coal special No. 3–C is 288 grams.

GAS AND DUST GALLERY NO. 1.

Date (1909).	Weight of charge.	Methane and ethane.	Result.	Date (1909).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Nov. 5	288	8.26	No ignition.	Nov. 8	288	....	No ignition.
Do	288	8.26	Do.	Do	288	....	Do.
Do	288	8.26	Do.	Do	288	....	Do.
Do	288	8.43	Do.	Do	288	....	Do.
Do	288	8.43	Do.	Do	288	....	Do.
Do	288	8.26	Do.	Do	288	....	Do.
Do	288	8.26	Do.	Do	288	....	Do.
Nov. 6	288	8.26	Do.				
Do	288	8.43	Do.	TEST 4.			
Do	288	8.43	Do.				
				Nov. 8	[a] 680	3.77	No ignition.
TEST 3.				Do	[a] 680	3.95	Do.
				Nov. 9	[a] 680	3.95	Do.
Nov. 8	288	....	No ignition.	Do	[a] 680	4.07	Do.
Do	288	....	Do.	Do	[a] 680	4.13	Do.
Do	288	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.

Electric detonator, No. 7.

Date (1909).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Nov. 5	14.11	43.0	3,047
Do	14.72	43.0	2,921
Nov. 6	14.51	43.0	2,963

Average rate of detonation, 2,977 meters (9,760 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Sept. 21	12.25	15.47	4.75	0.238
Do	12.50	15.79	4.75	.238
Do	11.25	14.21	4.50	.225

Average height of flame, 15.16 inches.

Average duration of flame, 0.234 millisecond.

IMPACT TEST.

Date, June 24, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	No explosion.	24	1	Explosion.
22	1	Do.	22	1	No explosion.
24	1	Do.	22	1	Explosion.
26	1	Explosion.	21	2	No explosion.
25	1	No explosion.	21	1	Explosion.
25	1	Explosion.	20	4	No explosion.

The maximum height at which no explosion occurs established at 20 centimeter (7.87 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 180 grams.

Date (1910).	Distance separating cartridges.	Result, upper cartridge.	Date (1910).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
July 16	10	Did not explode.	July 16	10	Did not explode.
Do	9	Exploded.	July 18	10	Do.

The minimum distance at which no explosion occurs established at 10 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

Date (1910).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
June 16	213	1.12	27.00	67.50	A	67.29
Do	213	1.12	26.75	66.88	A	
Do	213	1.12	27.00	67.50	A	
Sept. 14	213	1.12	26.25	65.62	B	64.37
Do	213	1.12	25.50	63.75	B	
Sept. 15	213	1.12	25.50	63.75	B	
Do	213	1.12	24.50	61.25	C	62.29
Do	213	1.12	25.00	62.50	C	
Sept. 24	213	1.12	25.25	63.12	C	

[a] Including 13 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=72.88$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.12$. $W=213$ grams.

$M=\frac{VPS}{W}=5{,}748$ kilograms per square centimeter (81,760 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 13 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 22, 1910.

	Grams.
Solid	79.8
Liquid (water)	13.2
Gaseous	118.8

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.5 grams.[a]

Date (1910).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°*C.*	*Calories.*
June 13	81.95	0.773	670.6
June 14	81.95	.796	690.8
Do	81.95	.775	672.3

[a] Including 6.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 677.9.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 12	63.00	51.00	12.00
Do	63.00	51.00	12.00
Do	63.00	50.75	12.25

Average compression, 12.1 millimeters (0.48 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
June 2	63	226	163	15
Do	63	213	150	15
Do	63	223	160	15

Average expansion of bore hole, 158 cubic centimeters (9.64 cubic inches).

COLLIER POWDER B, N. F.

Explosive, Collier powder B, N. F.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Keystone National Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 168 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 0.99.
  Color of explosive, drab.
  Consistency, granular and fibrous, fine, dry, soft, moderately cohesive.

Unit deflective charge as determined by ballistic pendulum
Date, January 2, 1913.
Unit swing on this date, 3.40 inches.
Weight of charge, in grams, 230, 230, 230.
Swing, in inches, 3.51, 3.43, 3.52.
Average swing, in inches, 3.49.

3.49 : 3.40 : : 230 : (224).

Therefore the unit deflective charge of Collier powder B, N. F., is 224 grams.

GAS AND DUST GALLERY NO. 1.

Date (1913).	Weight of charge.	Methane and ethane.	Result.	Date (1913).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Jan. 6	224	7.88	No ignition.	Jan. 10	224	....	No ignition.
Jan. 7	224	7.94	Do.	Do	224	....	Do.
Do	224	8.13	Do.	Jan. 11	224	....	Do.
Do	224	7.90	Do.	Do	224	....	Do.
Do	224	8.03	Do.	Do	224	....	Do.
Do	224	8.24	Do.	Do	224	....	Do.
Do	224	8.16	Do.	Do	224	....	Do.
Do	224	7.99	Do.				
Do	224	7.81	Do.	TEST 4.			
Do	224	7.76	Do.				
				Jan. 8	[a]680	3.93	No ignition.
TEST 3.				Do	[a]680	4.11	Do.
				Do	[a]680	4.00	Do.
Jan. 10	224	....	No ignition.	Do	[a]680	3.99	Do.
Do	224	....	Do.	Do	[a]680	3.94	Do.
Do	224	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1913).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Jan. 7	12.60	42.0	3,333
Jan. 8	12.40	42.0	3,387
Jan. 14	12.75	42.0	3,294

Average rate of detonation, 3,338 meters (10,950 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Feb. 20	10.50	13.26	6.25	0.312
Do	9.75	12.32	6.50	.325
Do	10.50	13.26	6.75	.338

Average height of flame, 12.95 inches.
Average duration of flame, 0.325 millisecond.

IMPACT TEST.

Date, March 4, 1913.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
30	1	No explosion.	35	3	No explosion.
38	1	Explosion.	35	1	Explosion.
34	1	No explosion.	34	1	Do.
36	1	Do.	33	2	No explosion.
37	3	Do.	33	1	Explosion.
37	1	Explosion.	32	3	No explosion.
36	1	No explosion.	32	1	Explosion.
36	1	Explosion.	31	5	No explosion.

The maximum height at which no explosion occurs established at 31 centimeters (12.20 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 159 grams.

Date (1913).	Distance separating cartridges.	Result, upper cartridge.	Date (1913).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Feb. 26	4	Did not explode.	Feb. 26	4	Did not explode.
Do	3	Exploded.	Do	4	Do.

The minimum distance at which no explosion occurs established at 4 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.24 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 14	217	0.99	23.25	96.88	A	96.18
Feb. 15	217	.99	22.75	94.79	A	
Do	217	.99	23.25	96.88	A	
Do	217	.99	22.75	94.79	B	94.79
Feb. 18	217	.99	22.75	94.79	B	
Do	217	.99	22.75	94.79	B	
Do	217	.99	22.00	91.67	C	92.71
Do	217	.99	22.50	93.75	C	
Do	217	.99	22.25	92.71	C	

[a] Including 17 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=100.38$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=0.99$. $W=217$ grams.

$M=\frac{VPS}{W}=6,869$ kilograms per square centimeter (97,700 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 17 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, January 16, 1913.

	Grams.
Solid	21.2
Liquid (water)	59.5
Gaseous	129.5

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 108.5 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat deve oped per kilogram
	Kilograms.	°C.	*Calories.*
Feb. 14	81.95	1.135	970.
Feb. 15	81.95	1.139	973.
Do	81.95	1.119	956.

[a] Including 8.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 966.7.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1913).	Height.		Compression
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Feb. 25	63.50	49.00	14.5
Do	63.50	49.50	14.0
Mar. 18	63.50	49.50	14.0

Average compression, 14.2 millimeters (0.56 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1913).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°C.
Mar. 5	63	315	252	1
Do	63	310	247	1
Do	63	305	242	1

Average expansion of bore hole, 247 cubic centimeters (15.07 cubic inches).

COLLIER POWDER KN.

Explosive, Collier powder KN.

Class 1*a*, ammonium nitrate, containing nitroglycerin.

Manufactured by the Keystone National Powder Co.

Physical examination:

- Diameter of cartridge, 1¼ inches.
- Length of cartridge, 8 inches.
- Average weight, 137 grams.
- Two inches of one end of cartridge had been redipped.
- Apparent specific gravity of cartridge by sand, 0.99.
- Color of explosive, corn.
- Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by ballistic pendulum:

Date, June 3, 1912.
Unit swing on this date, 3.27 inches.
Weight of charge, in grams, 225, 225, 225.
Swing, in inches, 3.32, 3.36, 3.26.
Average swing, in inches, 3.31.

3.31 : 3.27 : : 225 : (222).

Therefore the unit deflective charge of Collier powder KN is 222 grams.

GAS AND DUST GALLERY NO. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
June 4	222	8.21	No ignition.
Do	222	7.81	Do.
Do	222	8.12	Do.
Do	222	8.08	Do.
Do	222	7.94	Do.
Do	222	8.37	Do.
June 5	222	8.00	Do.
Do	222	7.79	Do.
Do	222	8.32	Do.
Do	222	8.27	Do.
TEST 3.			
June 6	222	....	No ignition.
Do	222	....	Do.
Do	222	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
June 6	222	....	No ignition.
Do	222	....	Do.
Do	222	....	Do.
Do	222	....	Do.
Do	222	....	Do.
Do	222	....	Do.
Do	222	....	Do.
TEST 4.			
June 5	[a] 680	4.17	No ignition.
June 6	[a] 680	4.07	Do.
Do	[a] 680	4.18	Do.
Do	[a] 680	4.18	Do.
Do	[a] 680	4.07	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
June 7	12.35	44.0	3,563
Do	12.75	44.5	3,490
Do	12.35	44.0	3,563

Average rate of detonation, 3,539 meters (11,610 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Sept. 5	4.50	5.68	1.25	0.062
Sept. 13	6.50	8.21	1.50	.075
Do	8.50	10.74	1.50	.075

Average height of flame, 8.21 inches.
Average duration of flame, 0.071 millisecond.

IMPACT TEST.

Date, August 20, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
40	1	Explosion.	26	1	Explosion.
20	1	No explosion.	25	1	Do.
30	1	Explosion.	24	5	No explosion.
27	1	Do.			

The maximum height at which no explosion occurs established at 24 centimeters (9.45 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 159 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Sept. 9	3	Exploded.	Sept. 9	4	Did not explode.
Do	4	Did not explode.	Do	4	Do.

The minimum distance at which no explosion occurs established at 4 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Aug. 26	216	0.99	32.75	102.34	A	104.17
Do	216	.99	33.75	105.47	A	
Aug. 27	216	.99	33.50	104.69	A	
Do	216	.99	30.00	93.75	B	93.75
Do	216	.99	30.25	94.53	B	
Do	216	.99	29.75	92.97	B	
Do	216	.99	29.25	91.41	C	92.97
Do	216	.99	29.50	92.19	C	
Do	216	.99	30.50	95.31	C	

[a] Including 16 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=114.76$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=0.99$. $W=216$ grams.

$M=\frac{VPS}{W}=7{,}890$ kilograms per square centimeter (112,220 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 16 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 13, 1912.	Grams.
Solid	4.0
Liquid (water)	71.5
Gaseous	126.0

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 108.0 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Sept. 23	81.95	1.250	1,074.2
Do	81.95	1.279	1,099.4
Sept. 25	81.95	1.229	1,056.0

[a] Including 8.0 grams of the original wrapper.

Average large calories per kilogram of explosive, 1,076.5.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Sept. 23	63.25	45.00	18.25
Do	63.25	45.00	18.25
Sept. 24	63.25	44.75	18.50

Average compression, 18.3 millimeters (0.72 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Oct. 17	62	336	274	15
Do	62	326	264	15
Dec. 17	63	328	265	15

Average expansion of bore hole, 268 cubic centimeters (16.35 cubic inches).

COLLIER POWDER NO. X.

Explosive, Collier powder No. X.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Keystone National Powder Co.
Physical examination:
  Diameter of cartridge, 1⅛ inches.
  Length of cartridge, 8 inches.
  Average weight, 148 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.06.
  Color of explosive, straw.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, August 15, 1910.
Unit swing on this date, 3.18 inches.
Weight of charge, in grams, 265, 265, 265.
Swing, in inches, 3.04, 3.05, 3.18.
Average swing, in inches, 3.09.

3.09 : 3.18 : : 265 : (273).

Therefore the unit deflective charge of Collier powder No. X is 273 grams.

GAS AND DUST GALLERY No. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Aug. 18	273	7.90	No ignition.
Do	273	8.06	Do.
Do	273	8.18	Do.
Do	273	7.90	Do.
Do	273	8.04	Do.
Do	273	7.90	Do.
Do	273	8.16	Do.
Aug. 24	273	8.05	Do.
Do	273	7.90	Do.
Do	273	8.25	Do.
TEST 3.			
Aug. 19	273	....	No ignition.
Do	273	....	Do.
Do	273	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Aug. 19	273	....	No ignition.
Do	273	....	Do.
Do	273	....	Do.
Do	273	....	Do.
Do	273	....	Do.
Do	273	....	Do.
Do	273	....	Do.
TEST 4.			
Aug. 22	[a] 680	4.10	No ignition.
Aug. 23	[a] 680	4.01	Do.
Do	[a] 680	4.10	Do.
Do	[a] 680	4.10	Do.
Aug. 27	[a] 680	4.05	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Aug. 24	17.78	43.0	2,41
Aug. 30	18.78	43.5	2,31
Aug. 31	17.99	43.5	2,41

Average rate of detonation, 2,384 meters (7,820 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 13	9.00	11.37	4.00	0.20
Do	13.25	16.74	5.00	.25
Do	11.00	13.90	4.25	.21

Average height of flame, 14 inches.
Average duration of flame, 0.221 millisecond.

IMPACT TEST.

Date, February 1, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
18	1	Explosion.	16	1	No explosion.
17	3	No explosion.	16	1	Explosion.
17	1	Explosion.	15	5	No explosion.

The maximum height at which no explosion occurs established at 15 centimeters (5.91 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 171 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Feb. 11	3	Did not explode.	Feb. 11	2	Did not explode.
Do	2	Do.	Do	2	Do.
Do	1	Exploded.			

The minimum distance at which no explosion occurs established at 2 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 4	218	1.06	30.20	94.40	A	94.90
Do	218	1.06	30.50	95.30	A	
Feb. 6	218	1.06	30.40	95.00	A	
Do	218	1.06	28.75	89.84	B	89.06
Feb. 7	218	1.06	28.00	87.50	B	
Do	218	1.06	28.75	89.84	B	
Feb. 6	218	1.06	26.75	83.59	C	83.85
Do	218	1.06	27.25	85.15	C	
Feb. 7	218	1.06	26.50	82.81	C	

[a] Including 18 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=107.57$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.06$. $W=218$ grams.

$M=\frac{VPS}{W}=7{,}846$ kilograms per square centimeter (111,600 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 18 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, September 12, 1910.

	Grams.
Solid	17.0
Liquid (water)	77.0
Gaseous	103.3

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 109.0 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat devel oped per kilogram.
	Kilograms.	*° C.*	*Calories.*
Feb. 8	81. 55	1. 170	991. 4
Do	81. 55	1. 137	963. 3
Do	81. 55	1. 163	985. 2

[a] Including 9 grams of the original wrapper.

Average large calories per kilogram of explosive, 980.0.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Jan. 24	63. 75	52. 25	11. 50
Do	63. 50	52. 00	11. 50
Do	63. 50	52. 00	11. 50

Average compression, 11.5 millimeters (0.45 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Jan. 27	63	212	149	15
Do	63	209	146	15
Do	63	212	149	15

Average expansion of bore hole, 148 cubic centimeters (9.03 cubic inches).

COLLIER POWDER X, L. F.

Explosive, Collier powder X, L. F.

Class 1*a*, ammonium nitrate, containing nitroglycerin.

Manufactured by the Keystone National Powder Co.

Physical examination:

- Diameter of cartridge, 1¼ inches.
- Length of cartridge, 8 inches.
- Average weight, 173 grams.
- Only one end of cartridge had been redipped.
- Apparent specific gravity of cartridge by sand, 1.06.
- Color of explosive, corn.
- Consistency, powdered and granular, very fine, very dry, very soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, December 28, 1911.
Unit swing on this date, 3.42 inches.
Weight of charge, in grams, 250, 250, 250.
Swing, in inches, 3.45, 3.43, 3.30.
Average swing, in inches, 3.39.

3.39 : 3.42 : : 250 : (252).

Therefore the unit deflective charge of Collier powder X, L. F., is 252 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911–12).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Dec. 30	252	8.21	No ignition.
Do	252	8.07	Do.
Do	252	8.37	Do.
Do	252	7.95	Do.
Do	252	7.95	Do.
Jan. 2	252	8.09	Do.
Do	252	8.42	Do.
Do	252	8.04	Do.
Do	252	8.29	Do.
Do	252	8.16	Do.
TEST 3.			
Jan. 8	252	....	No ignition.
Do	252	....	Do.
Do	252	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Jan. 8	252	....	No ignition.
Do	252	....	Do.
Do	252	....	Do.
Do	252	....	Do.
Do	252	....	Do.
Do	252	....	Do.
Do	252	....	Do.
TEST 4.			
Jan. 5	[a] 680	4.09	No ignition.
Do	[a] 680	3.85	Do.
Jan. 6	[a] 680	4.14	Do.
Do	[a] 680	4.01	Do.
Do	[a] 680	4.10	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Dec. 29	14.50	44.5	3,068
Do	14.65	44.5	3,038
Do	14.50	44.0	3,034

Average rate of detonation, 3,047 meters (9,990 feet per second).

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 8	9.00	11.37	3.00	0.150
Do	14.50	18.32	4.50	.225
Do	14.00	17.68	4.00	.200

Average height of flame, 15.79 inches.
Average duration of flame, 0.192 millisecond.

IMPACT TEST.

Date, February 26, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
15	1	No explosion.	16	3	No explosion.
18	1	Do.	16	1	Explosion.
20	1	Explosion.	15	1	No explosion.
19	3	No explosion.	15	1	Explosion.
19	1	Explosion.	14	1	No explosion.
18	1	No explosion.	14	1	Explosion.
18	1	Explosion.	13	5	No explosion.
17	1	Do.			

The maximum height at which no explosion occurs established at 13 centimeters (5.12 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 171 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Apr. 4	3	Exploded.	Apr. 4	6	Did not explode.
Do	4	Do.	Do	6	Do.
Do	5	Do.	Do	6	Do.

The minimum distance at which no explosion occurs established at 6 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Apr. 5	213	1.06	31.25	97.66	A	98.18
Apr. 6	213	1.06	31.50	98.44	A	
Do	213	1.06	31.50	98.44	A	
Apr. 5	213	1.06	28.50	89.06	B	88.80
Do	213	1.06	28.00	87.50	B	
Do	213	1.06	28.75	89.84	B	
Apr. 4	213	1.06	28.25	88.28	C	88.80
Apr. 5	213	1.06	28.75	89.84	C	
Do	213	1.06	28.25	88.28	C	

[a] Including 13 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=106.73$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.06$. $W=213.0$ grams.

$M=\frac{VPS}{W}=7{,}967$ kilograms per square centimeter (113,320 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 13 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, January 24, 1912.

	Grams.
Solid	19.7
Liquid (water)	70.0
Gaseous	108.5

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms	°*C.*	*Calories.*
Mar. 1	81.95	1.229	1,070.9
Mar. 2	81.95	1.225	1,093.7
Mar. 4	81.95	1.249	1,088.4

[a] Including 6.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 1,084.3.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 28	63.50	48.75	14.75
Do	63.50	49.25	14.25
Do	63.50	49.00	14.50

Average compression, 14.5 millimeters (0.57 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Feb. 23	62	240	178	15
Do	62	238	176	15
Do	62	246	184	15

Average expansion of bore hole, 179 cubic centimeters (10.92 cubic inches).

COLLIER POWDER NO. 5–L. F.

Explosive, Collier powder No. 5–L. F.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Keystone National Powder Co.
Physical examination:
  Diameter of cartridge, 1⅛ inches.
  Length of cartridge, 8 inches.
  Average weight, 151 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.06.
  Color of explosive, straw.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, August 15, 1910.
Unit swing on this date, 3.18 inches.
Weight of charge, in grams, 236, 236, 236.
Swing, in inches, 3.26, 3.22, 3.23.
Average swing, in inches, 3.24.

3.24 : 3.18 : : 236 : (232).

Therefore the unit deflective charge of Collier powder No. 5–L. F. is 232 grams.

GAS AND DUST GALLERY NO. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Aug. 17	232	7.90	No ignition.
Do	232	7.90	Do.
Do	232	7.84	Do
Aug. 18	232	8.14	Do.
Do	232	7.85	Do.
Do	232	8.37	Do.
Do	232	8.10	Do.
Do	232	8.02	Do.
Do	232	7.99	Do.
Do	232	9.34	Do.
TEST 3.			
Aug. 19	232	....	No ignition.
Do	232	....	Do.
Do	232	....	Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Aug. 19	232	....	No ignition.
Do	232	....	Do.
Do	232	....	Do.
Do	232	....	Do.
Do	232	....	Do.
Do	232	....	Do.
Do	232	....	Do.
TEST 4.			
Aug. 22	[a] 680	4.22	No ignition.
Do	[a] 680	4.20	Do.
Do	[a] 680	4.15	Do.
Do	[a] 680	4.10	Do.
Do	[a] 680	4.20	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Aug. 29	15.07	43.5	2,887
Aug. 30	15.57	43.5	2,794
Do	15.04	43.5	2,892

Average rate of detonation, 2,858 meters (9,370 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 13	16.50	20.84	7.25	0.363
Do	18.25	23.05	8.00	.400
Do	14.00	17.68	6.25	.313

Average height of flame, 20.52 inches.
Average duration of flame, 0.359 millisecond.

IMPACT TEST.

Date, January 31, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
26	1	Explosion.	17	1	No explosion.
24	1	Do.	17	1	Explosion.
22	1	Do.	16	1	No explosion.
18	1	Do.	16	1	Explosion.
16	1	No explosion.	15	5	No explosion.

The maximum height at which no explosion occurs established at 15 centimeters (5.91 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 171 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Jan. 30	4	Did not explode.	Jan. 30	3	Exploded.
Do	3	Do.	Do	4	Did not explode.
Do	2	Exploded.	Do	4	Do.

The minimum distance at which no explosion occurs established at 4 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 3	217	1.06	32.40	101.25	A	103.54
Feb. 4	217	1.06	33.40	104.38	A	
Do	217	1.06	33.60	105.00	A	
Jan. 24	217	1.06	31.00	96.88	B	97.40
Feb. 6	217	1.06	31.50	98.44	B	
Do	217	1.06	31.00	96.88	B	
Jan. 24	217	1.06	29.80	93.12	C	93.12
Do	217	1.06	29.60	92.50	C	
Do	217	1.06	30.00	93.75	C	

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[a] Including 17 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=115.17$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.06$. $W=217$ grams.

$M=\frac{VPS}{W}=8{,}439$ kilograms per square centimeter (120,040 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 17 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, September 12, 1910.

	Grams.
Solid	15.0
Liquid (water)	80.0
Gaseous	110.4

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 108.5 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°*C.*	*Calories.*
Feb. 7	81.55	1.297	1,105.
Do	81.55	1.295	1,103.
Do	81.55	1.294	1,102.

[a] Including 8.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 1,103.5.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Jan 24	63.25	48.50	14.7
Do	63.50	48.75	14.7
Do	63.50	49.00	14.5

Average compression, 14.7 millimeters (0.58 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Jan. 27	63	254	191	1
Do	63	249	186	1
Do	63	250	187	1

Average expansion of bore hole, 188 cubic centimeters (11.47 cubic inches).

COLLIER POWDER NO. 5 SPECIAL.

Explosive, Collier powder No. 5 special.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Keystone National Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 138 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.03.
  Color of explosive, straw.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, August 15, 1910.

Unit swing on this date, 3.18 inches.

Weight of charge, in grams, 230, 230, 230.

Swing, in inches, 3.12, 3.07, 3.12.

Average swing, in inches, 3.10.

3.10 : 3.18 : : 230 : (236).

Therefore the unit deflective charge of Collier powder No. 5 special is 236 grams.

GAS AND DUST GALLERY NO. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Aug. 17	236	8.64	No ignition.
Do	236	8.77	Do.
Do	236	8.78	Do.
Do	236	8.55	Do.
Do	236	8.37	Do.
Do	236	8.14	Do.
Do	236	8.02	Do.
Do	236	7.86	Do.
Do	236	7.90	Do.
Do	236	8.20	Do.
TEST 3.			
Aug. 18	236	....	No ignition.
Do	236	....	Do.
Do	236	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Aug. 18	236	....	No ignition.
Do	236	....	Do.
Aug. 19	236	....	Do.
Do	236	....	Do.
Do	236	....	Do.
Do	236	....	Do.
Do	236	....	Do.
TEST 4.			
Aug. 20	[a] 680	3.87	No ignition.
Do	[a] 680	4.06	Do.
Aug. 22	[a] 680	3.95	Do.
Do	[a] 680	3.95	Do.
Do	[a] 680	4.20	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.

Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Aug. 27	17.22	43.5	2,526
Do	17.07	43.5	2,548
Aug. 29	17.06	43.5	2,550

Average rate of detonation, 2,541 meters (8,330 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 13	16.00	20.21	7.50	0.375
Do	15.00	18.95	6.00	.300
Do	13.50	17.05	5.75	.288

Average height of flame, 18.74 inches.

Average duration of flame, 0.321 millisecond.

Impact Test.

Date, January 31, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
18	1	No explosion.	22	1	Explosion.
22	1	Do.	20	1	No explosion.
24	1	Explosion.	21	5	Do.
23	1	Do.			

The maximum height at which no explosion occurs established at 21 centimeter (8.27 inches).

Explosion-by-Influence Test.

Weight of each cartridge, 167 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Jan. 25	4	Did not explode.	Jan. 26	3	Exploded.
Do	2	Exploded.	Jan. 28	4	Did not explode.
Jan. 26	3	Did not explode.	Do	4	Do.
Do	3	Do.			

The minimum distance at which no explosion occurs established at 4 inches.

Theoretical Maximum Pressure Developed in Own Volume, as Determine by Bichel Pressure Gage.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per squar centimete
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 3	[b] 218	1.03	41.50	103.75	A	101.1
Do	218	1.03	32.20	100.62	A	
Do	218	1.03	31.80	99.38	A	
Jan. 23	[b] 218	1.03	38.60	96.50	B	98.2
Do	218	1.03	31.60	98.75	B	
Do	218	1.03	31.80	99.38	B	
Do	218	1.03	29.50	92.19	C	92.5
Do	218	1.03	29.80	93.12	C	
Jan. 24	218	1.03	29.50	92.19	C	

[a] Including 18 grams of the original wrapper.
[b] Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

$P=1.911A+0.5B-1.411C=111.93$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.03$. $W=218$ grams.

$$M=\frac{VPS}{W}=7{,}933$$ kilograms per square centimeter (112,840 pounds per square inch)

Products of Combustion from 200 Grams of the Explosive and 18 Grams o the Original Wrapper.

[Analyst, A. L. Hyde.]

Date, September 9, 1910.

	Grams
Solid	11.
Liquid (water)	81.
Gaseous	112.

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 109.0 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Feb. 6	81.55	1.320	1,119.5
Do	81.55	1.310	1,111.0
Do	81.55	1.310	1,111.0

[a] Including 9 grams of the original wrapper.

Average large calories per kilogram of explosive, 1,113.8.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Jan. 24	63.50	50.25	13.25
Do	63.50	50.75	12.75
Do	63.50	50.75	12.75

Average compression, 12.9 millimeters (0.51 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Jan. 27	63	258	195	15
Do	63	250	187	15
Feb. 15	63	257	194	15

Average expansion of bore hole, 192 cubic centimeters (11.71 cubic inches).

COLLIER POWDER NO. 6-L. F

Explosive, Collier powder No. 6-L. F.
Class 4, nitroglycerin.
Manufactured by the Keystone National Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8½ inches.
  Average weight, 170 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 1.02.
  Color of explosive, corn.
  Consistency, fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:
Date, September 26, 1910.
Unit swing on this date, 3.32 inches.
Weight of charge, in grams, 308, 308, 308.
Swing in inches, 3.30, 3.20, 3.20.
Average swing, in inches, 3.23.
3.23 : 3.32 : : 308 : (317).

Therefore the unit deflective charge of Collier powder No. 6–L. F. is 317 grams.

GAS AND DUST GALLERY NO. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.	Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*		TEST 3—Con.	*Grams.*	*Per cent.*	
Sept. 28	317	8.35	No ignition.	Sept. 29	317		No ignition.
Do	317	8.52	Do.	Do	317		Do.
Do	317	8.31	Do.	Do	317		Do.
Do	317	8.31	Do.	Do	317		Do.
Do	317	8.43	Do.	Do	317		Do.
Do	317	8.43	Do.	Do	317		Do.
Do	317	8.43	Do.	Do	317		Do.
Do	317	8.23	Do.				
Do	317	8.33	Do.	TEST 4.			
Do	317	8.33	Do.				
				Sept. 30	[a] 680	4.40	No ignition.
TEST 3.				Do	[a] 680	4.20	Do.
				Do	[a] 680	4.30	Do.
Sept. 29	317		No ignition.	Do	[a] 680	4.45	Do.
Do	317		Do.	Do	[a] 680	4.40	Do.
Do	317		Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Oct. 3	14.78	43.5	2,943
Do	14.44	43.5	3,012
Oct. 4	15.12	43.5	2,877

Average rate of detonation, 2,944 meters (9,660 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 21	11.75	14.84	5.75	0.288
Do	9.75	12.32	4.25	.212
Do	12.00	15.16	5.00	.250

Average height of flame, 14.11 inches.
Average duration of flame, 0.250 millisecond.

IMPACT TEST.

Date, February 24, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
40	1	Explosion.	31	1	No explosion.
30	1	No explosion.	31	1	Explosion.
32	1	Explosion.	30	5	No explosion.

The maximum height at which no explosion occurs established at 30 centimeters (11.81 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 164 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Feb. 27	6	Did not explode.	Feb. 28	2	Exploded.
Do	5	Do.	Do	3	Did not explode.
Do	3	Do.	Do	3	Do.
Do	1	Exploded.			

The minimum distance at which no explosion occurs established at 3 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Mar. 23	215	1.02	24.50	61.25	A	61.04
Do	215	1.02	24.50	61.25	A	
Do	215	1.02	24.25	60.62	A	
Mar. 17	[b] 215	1.02	19.00	59.38	B	58.33
Do	215	1.02	23.25	58.12	B	
Do	215	1.02	23.00	57.50	B	
Do	215	1.02	22.50	56.25	C	56.04
Mar. 18	215	1.02	22.25	55.62	C	
Do	215	1.02	22.50	56.25	C	

[a] Including 15 grams of the original wrapper.
[b] Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

$P=1.911A+0.5B-1.411C=66.75$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.02$. $W=215$ grams.

$M=\frac{VPS}{W}=4{,}750$ kilograms per square centimeter (67,560 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 15 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, March 1, 1911.

	Grams.
Solid	59.1
Liquid (water)	11.2
Gaseous	130.3

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.5 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°C.	*Calories.*
Mar. 6	80.95	0.667	566.0
Mar. 9	80.95	.677	574.5
Do	80.95	.678	575.4

[a] Including 7.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 572.0.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 20	63.75	51.50	12.25
Do	64.00	51.00	13.00
Do	64.00	51.50	12.50

Average compression, 12.6 millimeters (0.50 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Mar. 22	63	194	131	15
Do	63	202	139	15
Do	63	197	134	15

Average expansion of bore hole, 135 cubic centimeters (8.24 cubic inches).

COLLIER NO. 9.

Explosive, Collier No. 9.

Class 1*a*, ammonium nitrate, containing nitroglycerin.

Manufactured by the Keystone National Powder Co.

Physical examination:

- Diameter of cartridge, 1¼ inches.
- Length of cartridge, 8 inches.
- Average weight, 192 grams.
- Cartridge had not been redipped.
- Apparent specific gravity of cartridge by sand, 1.15.
- Color of explosive, white and corn.
- Consistency, granular and powdered, very fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, February 20, 1911.

Unit swing on this date, 3.06 inches.

Weight of charge, in grams, 270, 270, 270.

Swing, in inches, 2.95, 2.90, 2.90.

Average swing, in inches, 2.92.

2.92 : 3.06 : : 270 : (283).

Therefore the unit deflective charge of Collier No. 9 is 283 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.	Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Feb. 21	283	8.05	No ignition.	Feb. 23	283	....	No ignition.
Do	283	7.86	Do.	Do	283	....	Do.
Do	283	7.84	Do.	Do	283	....	Do.
Do	283	7.86	Do.	Do	283	....	Do.
Do	283	7.90	Do.	Do	283	....	Do.
Do	283	7.81	Do.	Do	283	....	Do.
Do	283	7.94	Do.	Do	283	....	Do.
Do	283	7.88	Do.				
Do	283	8.00	Do.	TEST 4.			
Do	283	7.99	Do.				
				Feb. 23	[a] 680	3.98	No ignition.
TEST 3.				Do	[a] 680	3.95	Do.
				Do	[a] 680	3.93	Do.
Feb. 23	283	....	No ignition.	Feb. 24	[a] 680	3.87	Do.
Do	283	....	Do.	Do	[a] 680	3.94	Do.
Do	283	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.

Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Feb. 20	21.55	45.00	2,088
Feb. 21	22.23	45.25	2,036
Do	22.55	45.00	1,996

Average rate of detonation, 2,040 meters (6,690 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Jan. 30	3.50	4.42	1.00	0.050
Do	9.50	12.00	3.00	.150
Do	7.25	9.16	2.25	.112

Average height of flame, 8.53 inches.

Average duration of flame, 0.104 millisecond.

IMPACT TEST.

Date October 18, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
40	1	Explosion.	31	1	No explosion.
36	1	Do.	31	1	Explosion.
34	1	Do.	30	5	No explosion.
32	1	Do.			

The maximum height at which no explosion occurs established at 30 centimeters (11.81 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 187 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Nov. 4	3	Exploded.	Nov. 6	8	Exploded.
Do	4	Do.	Do	9	Do.
Do	5	Did not explode.	Nov. 7	10	Did not explode.
Nov. 6	5	Exploded.	Do	10	Do.
Do	6	Do.	Do	10	Do.
Do	7	Do.			

The minimum distance at which no explosion occurs established at 10 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Aug. 8	[b] 212	1.15	23.75	74.22	A	73.44
Do	[b] 212	1.15	23.50	73.44	A	
Do	[b] 212	1.15	23.25	72.66	A	
Do	212	1.15	27.00	67.50	B	68.54
Aug. 9	212	1.15	28.25	70.62	B	
Do	212	1.15	27.00	67.50	B	
Aug. 10	212	1.15	26.50	66.25	C	67.29
Do	212	1.15	26.50	66.25	C	
Do	212	1.15	27.75	69.38	C	

[a] Including 12 grams of the original wrapper.
[b] Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

$P=1.911A+0.5B-1.411C=79.67$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.15$. $W=212$ grams.

$M=\frac{VPS}{W}=6{,}483$ kilograms per square centimeter (92,220 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 12 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 20, 1911.	Grams.
Solid	35.8
Liquid (water)	58.0
Gaseous	113.0

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.0 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°*C.*	*Calories.*
July 28	80.95	0.833	718.8
July 29	80.95	.812	700.5
Do	80.95	.814	702.2

[a] Including 6 grams of the original wrapper.

Average large calories per kilogram of explosive, 707.2.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Oct. 23	63.25	51.75	11.50
Do	63.50	51.50	12.00
Oct. 24	64.00	52.50	11.50

Average compression, 11.7 millimeters (0.46 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Apr. 8	63	192	129	15
Do	63	192	129	15
Do	63	200	137	15

Average expansion of bore hole, 132 cubic centimeters (8.05 cubic inches).

COLLIER POWDER NO. 11.

Explosive, Collier powder No. 11.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Keystone National Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 174 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 1.04.
  Color of explosive, drab.
  Consistency, granular and fibrous, fine, dry, soft, moderately cohesive.

Unit deflective charge as determined by ballistic pendulum:

Date, January 2, 1913.

Unit swing on this date, 3.40 inches.

Weight of charge, in grams, 220, 220, 220.

Swing, in inches, 3.40, 3.53, 3.41.

Average swing, in inches, 3.45.

3.45 : 3.40 : : 220 : (217).

Therefore the unit deflective charge of Collier powder No. 11 is 217 grams.

GAS AND DUST GALLERY NO. 1.

Date (1913).	Weight of charge.	Methane and ethane.	Result.	Date (1913).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Jan. 6	217	7.91	No ignition.	Jan. 10	217	....	No ignition.
Do	217	7.90	Do.	Do	217	....	Do.
Do	217	8.21	Do.	Do	217	....	Do.
Do	217	7.91	Do.	Do	217	....	Do.
Do	217	8.20	Do.	Do	217	....	Do.
Do	217	7.75	Do.	Do	217	....	Do.
Do	217	8.13	Do.	Do	217	....	Do.
Do	217	7.92	Do.				
Do	217	7.91	Do.	TEST 4.			
Do	217	7.97	Do.				
				Jan. 8	[a]680	4.07	No ignition.
TEST 3.				Jan. 9	[a]680	4.00	Do.
				Do	[a]680	3.99	Do.
Jan. 10	217	....	No ignition.	Do	[a]680	3.93	Do.
Do	217	....	Do.	Do	[a]680	4.15	Do.
Do	217	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.

Electric detonator, No. 7.

Date (1913).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Jan. 6	11.65	42	3,605
Jan. 7	11.80	42	3,559
Jan. 8	11.65	41	3,519

Average rate of detonation, 3,561 meters (11,680 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Feb. 21	8.00	10.11	5.50	0.225
Do	9.00	11.37	6.25	.312
Do	8.75	11.05	6.75	.338

Average height of flame, 10.84 inches.

Average duration of flame, 0.292 millisecond.

IMPACT TEST.

Date, March 4, 1913.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
40	1	Explosion.	22	1	Explosion.
36	1	Do.	18	1	Do.
32	1	Do.	14	1	No explosion.
28	1	Do.	16	1	Do.
26	1	Do.	17	5	Do.

The maximum height at which no explosion occurs established at 17 centimeters (6.69 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 167 grams.

Date (1913).	Distance separating cartridges.	Result, upper cartridge.	Date (1913).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Feb. 27	4	Exploded.	Feb. 27	9	Exploded.
Do	6	Do.	Do	10	Did not explode.
Do	8	Do.	Do	10	Do.
Do	10	Did not explode.			

The minimum distance at which no explosion occurs established at 10 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.24 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 14	215	1.04	25.00	104.17	A	103.82
Do	215	1.04	24.75	103.12	A	
Feb. 15	215	1.04	25.00	104.17	A	
Feb. 14	215	1.04	24.75	103.12	B	102.78
Do	215	1.04	25.00	104.17	B	
Feb. 17	215	1.04	24.25	101.04	B	
Do	215	1.04	23.75	98.96	C	101.73
Do	215	1.04	24.75	103.12	C	
Do	215	1.04	24.75	103.12	C	

[a] Including 15 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=106.25$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=1.04$. $W=215$ grams.

$M=\frac{VPS}{W}=7,709$ kilograms per square centimeter (109,650 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 15 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, January 16, 1913.

	Grams.
Solid	4.7
Liquid (water)	69.0
Gaseous	129.2

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.5 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°*C.*	*Calories.*
Feb. 17	81.95	1.208	1,042.
Do	81.95	1.208	1,042.
Do	81.95	1.219	1,052.

[a] Including 7.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 1,045.9.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1913).	Height.		Compression
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Feb. 25	63.50	46.00	17.5
Do	63.25	46.00	17.2
Do	63.25	46.25	17.0

Average compression, 17.2 millimeters (0.67 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1913).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Mar. 6	63	310	247	1
Do	63	300	237	1
Do	63	307	244	1

Average expansion of bore hole, 243 cubic centimeters (14.82 cubic inches).

CRONITE NO. 1.

Explosive, Cronite No. 1.

Class 1*a*, ammonium nitrate, containing nitroglycerin.

Manufactured by the G. R. McAbee Powder & Oil Co.

Physical examination:

- Diameter of cartridge, 1¼ inches.
- Length of cartridge, 8 inches.
- Average weight, 155 grams.
- Cartridge had been redipped.
- Apparent specific gravity of cartridge by sand, 0.93.
- Color of explosive, straw.
- Consistency, granular, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by ballistic pendulum:

Date, October 28, 1912.
Unit swing on this date, 3.43 inches.
Weight of charge, in grams, 240, 240, 240.
Swing, in inches, 3.54, 3.48, 3.58.
Average swing, in inches, 3.53.

$$3.53 : 3.43 :: 240 : (233).$$

Therefore the unit deflective charge of Cronite No. 1 is 233 grams.

GAS AND DUST GALLERY NO. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	Grams.	Per cent.	
Oct. 29	233	8.17	No ignition.
Do	233	8.34	Do.
Do	233	8.33	Do.
Do	233	8.18	Do.
Do	233	8.34	Do.
Do	233	7.78	Do.
Do	233	8.45	Do.
Do	233	8.28	Do.
Oct. 30	233	7.95	Do.
Do	233	8.52	Do.
TEST 3.			
Nov. 4	233		No ignition.
Do	233		Do.
Do	233		Do.
TEST 3—Con.	Grams.	Per cent.	
Nov. 4	233		No ignition.
Do	233		Do.
Do	233		Do.
Do	233		Do.
Do	233		Do.
Do	233		Do.
Nov. 5	233		Do.
TEST 4.			
Oct. 31	[a]680	4.13	No ignition.
Do	[a]680	4.19	Do.
Nov. 1	[a]680	4.21	Do.
Do	[a]680	4.17	Do.
Do	[a]680	4.26	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	Meters.	Meters.
Oct. 28	13.20	42.0	3,182
Do	13.15	42.0	3,194
Do	13.05	42.0	3,218

Average rate of detonation, 3,198 meters (10,490 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	Inches.	Millimeters.	Milliseconds.
Feb. 20	10.75	13.58	6.00	0.300
Do	10.75	13.58	6.00	.300
Do	9.75	12.32	6.50	.325

Average height of flame, 13.16 inches.
Average duration of flame, 0.308 millisecond.

IMPACT TEST.

Date, November 7, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
10	1	No explosion.	26	1	Explosion.
20	1	Do.	25	1	No explosion.
30	1	Explosion.	25	1	Explosion.
24	1	No explosion.	24	1	Do.
27	1	Do.	23	2	No explosion.
29	4	Do.	23	1	Explosion.
29	1	Explosion.	22	1	Do.
28	3	No explosion.	21	3	No explosion.
28	1	Explosion.	21	1	Explosion.
27	1	Do.	20	1	Do.
.26	1	No explosion.	19	5	No explosion.

The maximum height at which no explosion occurs established at 19 centimete (7.48 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 150 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Nov. 11	2	Exploded.	Nov. 11	5	Exploded.
Do	3	Do.	Nov. 16	6	Did not explode.
Do	4	Did not explode.	Do	6	Do.
Do	4	Exploded.	Do	6	Do.

The minimum distance at which no explosion occurs established at 6 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMIN BY BICHEL PRESSURE GAGE.

Indicator spring, 0.24 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Averag pressur per squa centimet
	Grams.		*Millimeters.*	*Kilograms.*		*Kilogram*
Nov. 29	215	0.93	23.75	98.96	A	97.
Do	215	.93	23.75	98.96	A	
Do	215	.93	22.75	94.79	A	
Nov. 27	[b]215	.93	31.50	98.44	B	95.
Do	[b]215	.93	30.00	93.75	B	
Do	[b]215	.93	30.25	94.53	B	
Do	215	.93	20.50	85.42	C	84.
Do	215	.93	20.25	84.38	C	
Do	215	.93	20.25	84.38	C	

[a] Including 15 grams of the original wrapper.
[b] Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

$P=1.911A+0.5B-1.411C=114.69$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=0.93$. $W=215$ grams.

$M=\frac{VPS}{W}=7{,}442$ kilograms per square centimeter (105,850 pounds per square inch

roducts of Combustion from 200 Grams of the Explosive and 15 Grams of the Original Wrapper.

[Analyst, A. L. Hyde.]

Date, November 5, 1912.	Grams.
olid	21.0
iquid (water)	59.5
aseous	126.3

Large Calories Developed by 1 Kilogram of the Explosive.

Charge, 107.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°C.	Calories.
ec. 17	81.95	1.116	962.7
Do	81.95	1.151	993.1
Do	81.95	1.106	954.0

[a] Including 7.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 969.9.

Compression of Small Lead Blocks.

Charge, 100 grams.

Date (1913).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	Millimeters.	Millimeters.
eb. 25	63.50	49.25	14.25
Do	63.50	49.00	14.50
Do	62.75	48.75	14.00

Average compression, 14.2 millimeters (0.56 inch).

Expansion of Bore Hole of Trauzl Lead Blocks.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	Cubic centimeters.	Cubic centimeters.	°C.
ov. 14	62	338	276	15
Do	62	343	281	15
Do	62	351	289	15

Average expansion of bore hole, 282 cubic centimeters (17.20 cubic inches).

CRONITE NO. 5.

Explosive, Cronite No. 5.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the G. R. McAbee Powder & Oil Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 152 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 0.93.
  Color of explosive, corn.
  Consistency, granular and fibrous, fine, dry, soft, not cohesive.
Unit deflective charge as determined by ballistic pendulum:
  Date, October 28, 1912.
  Unit swing on this date, 3.43 inches.
  Weight of charge, in grams, 255, 255, 255.
  Swing, in inches, 3.43, 3.57, 3.53.
  Average swing, in inches, 3.51.

3.51 : 3.43 : : 255 : (249).

Therefore the unit deflective charge of Cronite No. 5 is 249 grams.

Gas and Dust Gallery No. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
Test 1.				Test 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Oct. 30	249	7.83	No ignition.	Nov. 5	249	....	No ignition.
Do	249	8.09	Do.	Do	249	....	Do.
Do	249	7.92	Do.	Do	249	....	Do.
Do	249	7.77	Do.	Do	249	....	Do.
Do	249	7.84	Do.	Do	249	....	Do.
Do	249	7.98	Do.	Do	249	....	Do.
Do	249	8.06	Do.				
Do	249	7.91	Do.				
Do	249	8.15	Do.	Test 4.			
Do	249	8.09	Do.				
				Nov. 1	[a] 680	4.12	No ignition.
Test 3.				Do	[a] 680	4.05	Do.
				Do	[a] 680	4.17	Do.
Nov. 5	249	....	No ignition.	Do	[a] 680	4.05	Do.
Do	249	....	Do.	Do	[a] 680	4.00	Do.
Do	249	....	Do.				

[a] 680 grams or more was used.

Rate of Detonation.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Oct. 30	16.70	42	2,5
Do	17.05	42	2,4
Nov. 1	17.35	42	2,4

Average rate of detonation, 2,466 meters (8,090 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Feb. 24	12.50	15.79	6.25	0.312
Do	10.50	13.26	5.50	.275
Do	11.25	14.21	4.75	.238

Average height of flame, 14.42 inches.

Average duration of flame, 0.275 millisecond.

IMPACT TEST.

Date, November 8, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
30	1	Explosion.	18	1	No explosion.
20	1	Do.	19	1	Explosion.
10	1	No explosion.	18	4	No explosion.
16	1	Do.			

The maximum height at which no explosion occurs established at 18 centimeters (7.09 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 150 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Nov. 11	4	Did not explode.	Nov. 11	2	Did not explode.
Do	2	Do.	Do	2	Do.
Do	1	Exploded.			

The minimum distance at which no explosion occurs established at 2 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.24 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Nov. 29	219	0.93	20.50	85.42	A	85.07
Do	219	.93	20.25	84.38	A	
Do	219	.93	20.50	85.42	A	
Nov. 30	219	.93	19.75	82.29	B	83.33
Do	219	.93	20.50	85.42	B	
Do	219	.93	19.75	82.29	B	
Do	219	.93	19.75	82.29	C	81.25
Dec. 2	219	.93	19.00	79.17	C	
Do	219	.93	19.75	82.29	C	

[a] Including 19 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=89.59$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=0.93.$ $W=219$ grams.

$M=\frac{VPS}{W}=5,707$ kilograms per square centimeter (81,170 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 19 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, November 5, 1912.	Grams.
Solid	25.7
Liquid (water)	61.5
Gaseous	126.4

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 109.5 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Jan. 7	81.95	1.069	904.9
Do	81.95	1.059	896.4
Do	81.95	1.085	918.6

[a] Including 9.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 906.6.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1913).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Feb. 24	63.50	50.75	12.75
Do	63.50	51.00	12.50
Do	63.50	51.25	12.25

Average compression, 12.5 millimeters (0.49 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°C.
Nov. 14	62	286	224	15
Do	62	286	224	15
Do	62	285	223	15

Average expansion of bore hole, 224 cubic centimeters (13.66 cubic inches).

DETONITE SPECIAL.

Explosive, Detonite special.
Class 1*a*, ammonium nitrate.
Manufactured by the King Powder Co.
Physical examination:
  Diameter of cartridge, 1½ inches.
  Length of cartridge, 12 inches.
  Average weight, 441 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 1.09.
  Color of explosive, drab.
  Consistency, granular, fine, dry, soft, slightly cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, February 1, 1910.
  Unit swing on this date, 3.14 inches.
  Weight of charge, in grams, 300, 300, 300.
  Swing, in inches, 3.02, 3.03, 3.00.
  Average swing, in inches, 3.02.

3.02 : 3.14 : : 300 : (312).

Therefore the unit deflective charge of Detonite special is 312 grams.

GAS AND DUST GALLERY NO. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.	Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 1—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Feb. 1	312	8.07	No ignition.	Feb. 2	312		No ignition.
Do	312	8.02	Do.	Do	312		Do.
Do	312	8.42	Do.	Do	312		Do.
Feb. 2	312	8.07	Do.	Feb. 3	312		Do.
Do	312	8.17	Do.	Do	312		Do.
Do	312	8.27	Do.	Do	312		Do.
Do	312	8.17	Do.	Do	312		Do.
Do	312	8.22	Do.				
Do	312	8.17	Do.	TEST 4.			
Do	312	8.27	Do.				
				Jan. 31	[a] 680	3.96	No ignition.
TEST 3.				Do	[a] 680	4.07	Do.
				Do	[a] 680	4.15	Do.
Feb. 2	312		No ignition.	Do	[a] 680	4.06	Do.
Do	312		Do.	Do	[a] 680	3.84	Do.
Do	312		Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Feb. 2	13.05	43.0	3,295
Do	13.11	43.0	3,280
Do	12.87	43.0	3,341

Average rate of detonation, 3,305 meters (10,840 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Jan. 30	5.00	6.32	1.50	0.075
Do	5.50	6.95	2.50	.125
Do	5.00	6.32	1.50	.075

Average height of flame, 6.53 inches.

Average duration of flame, 0.092 millisecond.

IMPACT TEST.

Date, November 11, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
8	1	No explosion.	18	1	Explosion.
16	1	Do.	12	1	No explosion.
32	1	Explosion.	14	1	Explosion.
24	1	No explosion.	13	1	Do.
28	1	Explosion.	12	2	No explosion.
26	1	Do.	12	1	Explosion.
25	1	Do.	11	1	Do.
24	1	Do.	10	5	No explosion.
20	1	Do.			

The maximum height at which no explosion occurs established at 10 centimeters (3.94 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 206 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Dec. 17	3	Did not explode.	Dec. 17	2	Exploded.
Do	2	Do.	Dec. 18	3	Did not explode.
Do	1	Exploded.	Do	3	Do.

The minimum distance at which no explosion occurs established at 3 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Dec. 4	238	0.84	26.50	82.81	A	82.29
Do	238	.84	26.50	82.81	A	
Do	238	.84	26.00	81.25	A	
Do	238	.84	25.25	78.91	B	79.95
Do	238	.84	25.50	79.69	B	
Do	238	.84	26.00	81.25	B	
Do	238	.84	23.25	72.66	C	73.18
Do	238	.84	23.00	71.88	C	
Do	238	.84	24.00	75.00	C	

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[a] Including 38 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=93.97$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=0.84$. $W=238$ grams.

$M=\frac{VPS}{W}=4{,}975$ kilograms per square centimeter (70,760 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 33 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, July 7, 1910.	Grams.
Solid	44.8
Liquid (water)	56.5
Gaseous	133.9

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 119.0 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°*C.*	*Calories.*
Dec. 9	81.95	0.912	709.3
Dec. 10	81.95	.930	723.5
Do	81.95	.940	731.3

[a] Including 19 grams of the original wrapper.

Average large calories per kilogram of explosive, 721.4.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
July 9	63.50	52.25	11.25
Do	63.50	51.50	12.00
Do	63.50	51.00	12.50

Average compression, 11.9 millimeters (0.47 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Nov. 15	63	222	159	15
Do	63	227	164	15
Nov. 18	63	219	156	15

Average expansion of bore hole, 160 cubic centimeters (9.76 cubic inches).

EUREKA NO. 2.

Explosive, Eureka No. 2.
Class 2, hydrated.
Manufactured by the G. R. McAbee Powder & Oil Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 202 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.15.
  Color of explosive, corn.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.
Unit deflective charge as determined by ballistic pendulum:
  Date, April 15, 1912.
  Unit swing on this date, 3.37 inches.
  Weight of charge, in grams, 295, 295, 295.
  Swing, in inches, 3.22, 3.20, 3.17.
  Average swing, in inches, 3.20.

3.20 : 3.37 : : 295 : (311).

Therefore the unit deflective charge of Eureka No. 2 is 311 grams.

Gas and Dust Gallery No. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Apr. 19	311	8.15	No ignition.
Do	311	8.14	Do.
Do	311	7.95	Do.
Do	311	8.02	Do.
Do	311	8.09	Do.
Do	311	7.97	Do.
Apr. 20	311	7.98	Do.
Do	311	8.26	Do.
Do	311	7.95	Do.
Do	311	7.94	Do.
TEST 3.			
Apr. 25	311	....	No ignition.
Do	311	....	Do.
Do	311	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Apr. 25	311	....	No ignition.
Do	311	....	Do.
Do	311	....	Do.
Do	311	....	Do.
Do	311	....	Do.
Do	311	....	Do.
Do	311	....	Do.
TEST 4.			
Apr. 22	[a] 680	4.12	No ignition.
Do	[a] 680	4.16	Do.
Do	[a] 680	4.07	Do.
Do	[a] 680	4.17	Do.
Do	[a] 680	4.12	Do.

[a] 680 grams or more was used.

Rate of Detonation.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
May 3	13.70	44.0	3,212
Do	13.75	44.5	3,236
Do	13.10	44.0	3,359

Average rate of detonation, 3.269 meters (10,720 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Aug. 28	8.00	10.11	3.00	0.150
Do	7.75	9.79	3.00	.150
Do	10.75	13.58	4.50	.225

Average height of flame, 11.16 inches.
Average duration of flame, 0.175 millisecond.

IMPACT TEST.

Date, August 20, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
40	1	Explosion.	16	1	Explosion.
30	1	Do.	15	1	Do.
20	1	Do.	14	1	Do.
15	1	No explosion.	13	5	No explosion.
18	1	Explosion.			

The maximum height at which no explosion occurs established at 13 centimeters (5.12 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 185 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Sept. 7	3	Exploded.	Sept. 7	7	Exploded.
Do	4	Do.	Do	8	Did not explode.
Do	5	Do.	Do	8	Do.
Do	6	Do.	Do	8	Do.

The minimum distance at which no explosion occurs established at 8 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Aug. 19	211	1.15	19.50	60.94	A	61.98
Do	211	1.15	20.00	62.50	A	
Aug. 20	211	1.15	20.00	62.50	A	
Do	211	1.15	18.25	57.03	B	57.03
Do	211	1.15	18.25	57.03	B	
Do	211	1.15	18.25	57.03	B	
Do	211	1.15	17.25	53.91	C	53.91
Aug. 21	211	1.15	17.25	53.91	C	
Do	211	1.15	17.25	53.91	C	

[a] Including 11 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=70.89$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.15$. $W=211$ grams.

$M=\frac{VPS}{W}=5{,}796$ kilograms per square centimeter (82,440 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 11 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, May 1, 1912.	Grams.
Solid	77.9
Liquid (water)	21.7
Gaseous	103.3

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 105.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
July 26	81.95	0.733	641.5
Do	81.95	.721	630.8
Do	81.95	.752	658.3

[a] Including 5.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 643.5.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Aug. 15	63.25	51.50	11.75
Do	63.25	51.50	11.75
Do	63.25	51.75	11.50

Average compression, 11.7 millimeters (0.46 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Sept. 27	62	181	119	15
Do	62	183	121	15
Do	62	184	122	15

Average expansion of bore hole, 121 cubic centimeters (7.38 cubic inches).

FORT PITT MINE POWDER NO. 1.

Explosive, Fort Pitt mine powder No. 1.
Class 4, nitroglycerin.
Manufactured by the Fort Pitt Powder Co.
Physical examination:
- Diameter of cartridge, 1¼ inches.
- Length of cartridge, 8 inches.
- Average weight, 173 grams.
- Cartridge had not been redipped.
- Apparent specific gravity of cartridge by sand, 1.04.
- Color of explosive, corn.
- Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:
- Date, March 21, 1912.
- Unit swing on this date, 3.59 inches.
- Weight of charge, in grams, 300, 300, 300.
- Swing, in inches, 3.77, 3.67, 3.60.
- Average swing, in inches, 3.68.

3.68 : 3.59 : : 300 : (293).

Therefore the unit deflective charge of Fort Pitt mine powder No. 1 is 293 grams.

Gas and Dust Gallery No. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Mar. 21	293	7.77	No ignition.
Do	293	7.81	Do.
Mar. 22	293	7.98	Do.
Do	293	7.75	Do.
Do	293	8.02	Do.
Do	293	8.11	Do.
Do	293	8.00	Do.
Do	293	7.92	Do.
Do	293	8.33	Do.
Do	293	8.46	Do.
TEST 3.			
Mar. 25	293	....	No ignition.
Do	293	....	Do.
Do	293	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Mar. 25	293	....	No ignition.
Do	293	....	Do.
Do	293	....	Do.
Do	293	....	Do.
Do	293	....	Do.
Do	293	....	Do.
Do	293	....	Do.
TEST 4.			
Mar. 25	[a] 680	4.21	No ignition.
Do	[a] 680	4.25	Do.
Mar. 26	[a] 680	3.93	Do.
Do	[a] 680	4.02	Do.
Do	[a] 680	3.99	Do.

[a] 680 grams or more was used.

Rate of Detonation.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Mar. 25	13.05	44.0	3,372
Do	12.80	44.5	3,477
Do	13.00	44.5	3,423

Average rate of detonation, 3,424 meters (11,230 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Aug. 28	11.75	14.84	3.25	0.162
Do	11.50	14.53	4.00	.200
Do	9.50	12.00	3.50	.175

Average height of flame, 13.79 inches.

Average duration of flame, 0.179 millisecond.

IMPACT TEST.

Date, May 17, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
25	1	Explosion.	10	1	No explosion.
20	1	Do.	13	1	Explosion.
15	1	Do.	12	5	No explosion.

The maximum height at which no explosion occurs established at 12 centimeters (4.72 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 166 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Nov. 6	8	Did not explode.	Nov. 6	6	Did not explode.
Do	4	Exploded.	Do	6	Do.
Do	5	Do.	Do	6	Do.

The minimum distance at which no explosion occurs established at 6 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
July 26	212	1.04	21.75	67.97	A	68.23
July 27	212	1.04	22.00	68.75	A	
July 29	212	1.04	21.75	67.97	A	
July 24	212	1.04	21.00	65.62	B	66.15
Do	212	1.04	21.25	66.41	B	
Do	212	1.04	21.25	66.41	B	
July 26	212	1.04	20.00	62.50	C	63.54
Do	212	1.04	20.75	64.84	C	
Do	212	1.04	20.25	63.28	C	

[a] Including 12 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=73.81$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.04$. $W=212$ grams.

$M=\frac{VPS}{W}=5{,}431$ kilograms per square centimeter (77,250 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 12.6 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, March 22, 1912.

	Grams.
Solid	62.3
Liquid (water)	11.2
Gaseous	129.5

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.5 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	° *C.*	*Calories.*
Feb. 10	81.95	0.925	804.0
Feb. 13	81.95	.895	777.7
Feb. 14	81.95	.934	811.9

[a] Including 6.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 797.9.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
May 18	63.25	50.00	13.25
Do	63.25	49.50	13.75
Do	63.00	49.75	13.25

Average compression, 13.4 millimeters (0.53 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Sept. 27	62	235	173	15
Do	62	236	174	15
Do	62	228	168	15

Average expansion of bore hole, 172 cubic centimeters (10.49 cubic inches).

FUEL-ITE NO. 1.

Explosive, Fuel-ite No. 1.
Class 4, nitroglycerin.
Manufactured by the Burton Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 180 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.10.
  Color of explosive, corn.
  Consistency, fibrous, fine, dry, very soft, slightly cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, June 19, 1911.
  Unit swing on this date, 2.98 inches.
  Weight of charge, in grams, 280, 280, 280.
  Swing, in inches, 2.97, 2.86, 2.86.
  Average swing, in inches, 2.90.

2.90 : 2.98 : : 280 : (288).

Therefore the unit deflective charge of Fuel-ite No. 1 is 288 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.	Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
June 20	288	8.01	No ignition.	June 24	288	....	No ignition.
June 21	288	7.87	Do.	Do	288	....	Do.
Do	288	7.85	Do.	Do	288	....	Do.
Do	288	8.18	Do.	Do	288	....	Do.
Do	288	8.26	Do.	Do	288	....	Do.
Do	288	7.96	Do.	Do	288	....	Do.
Do	288	8.12	Do.	Do	288	....	Do.
Do	288	8.05	Do.	Do	288	....	Do.
Do	288	8.10	Do.				
June 30	288	8.46	Do.	TEST 4.			
TEST 3.				June 28	[a] 680	3.95	No ignition.
				Do	[a] 680	3.82	Do.
June 24	288	....	No ignition.	Do	[a] 680	3.95	Do.
Do	288	....	Do.	Do	[a] 680	3.87	Do.
Do	288	....	Do.	June 29	[a] 680	3.87	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
June 13	14.04	48.00	3,419
June 14	15.05	51.75	3,439
Do	15.26	51.00	3,342

Average rate of detonation, 3,400 meters (11,150 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Jan. 2	21.75	27.47	10.50	0.525
Do	16.25	20.53	8.25	.412
Do	23.50	29.68	12.75	.638

Average height of flame, 25.89 inches.
Average duration of flame, 0.525 millisecond.

IMPACT TEST.

Date, December 28, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	18	1	Explosion.
12	1	No explosion.	16	2	No explosion.
13	1	Do.	16	1	Explosion.
14	1	Do.	15	5	No explosion.

The maximum height at which no explosion occurs established at 15 centimeters (5.91 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 180 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Jan. 19	2	Exploded.	Jan. 19	5	Did not explode.
Do	3	Do.	Do	5	Do.
Do	4	Did not explode.	Do	5	Do.
Do	4	Exploded.			

The minimum distance at which no explosion occurs established at 5 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Nov. 21	217	1.10	22.25	69.53	A	70.83
Do	217	1.10	22.50	70.31	A	
Do	217	1.10	23.25	72.66	A	
Nov. 20	217	1.10	21.50	67.19	B	67.71
Nov. 21	217	1.10	21.75	67.97	B	
Do	217	1.10	21.75	67.97	B	
Nov. 16	217	1.10	20.00	62.50	C	63.28
Do	217	1.10	20.00	62.50	C	
Nov. 17	217	1.10	20.75	64.84	C	

[a] Including 17 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=79.92$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.10$. $W=217$ grams.

$M=\frac{VPS}{W}=6{,}077$ kilograms per square centimeter (86,440 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 17 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, July 12, 1911.	Grams.
Solid	70. 6
Liquid (water)	10. 6
Gaseous	126. 8

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 108.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Jan. 23	81.95	0.808	688.4
Do	81.95	.822	700.5
Jan. 24	81.95	.782	666.0

[a] Including 8.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 685.0.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Nov. 21	63.50	49.25	14.25
Do	63.50	49.00	14.50
Do	63.50	49.00	14.50

Average compression, 14.4 millimeters (0.57 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Sept. 13	63	228	165	15
Do	63	226	163	15
Do	63	228	165	15

Average expansion of bore hole, 164 cubic centimeters (10.0 cubic inches).

FUEL-ITE NO. 2.

Explosive, Fuel-ite No. 2.
Class 4, nitroglycerin.
Manufactured by the Burton Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 168 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.02.
  Color of explosive, corn.
  Consistency, fibrous, fine, dry, very soft, slightly cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, June 19, 1911.
  Unit swing on this date, 2.98 inches.
  Weight of charge, in grams, 305, 305, 305.
  Swing, in inches, 3.12, 3.13, 3.17.
  Average swing, in inches, 3.14.

3.14 : 2.98 : : 305 : (289).

Therefore the unit deflective charge of Fuel-ite No. 2 is 289 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
June 22	289	7.97	No ignition.
Do	289	8.04	Do.
Do	289	8.23	Do.
Do	289	8.15	Do.
Do	289	8.04	Do.
Do	289	8.19	Do.
Do	289	8.27	Do.
Do	289	7.98	Do.
Do	289	8.01	Do.
July 31	289	7.89	Do.
TEST 3.			
June 26	289		No ignition.
Do	289		Do.
Do	289		Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
June 26	289		No ignition.
Do	289		Do.
Do	289		Do.
Do	289		Do.
Do	289		Do.
Do	289		Do.
Do	289		Do.
TEST 4.			
June 27	[a]680	4.02	No ignition.
Do	[a]680	3.94	Do.
Do	[a]680	3.92	Do.
Do	[a]680	3.93	Do.
Do	[a]680	3.82	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
June 19	17.54	43.50	2,480
Do	17.24	43.50	2,523
Do	17.18	43.50	2,532

Average rate of detonation, 2,512 meters (8,240 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Sept. 11	8.75	11.05	4.00	0.200
Do	8.75	11.05	3.75	.188
Do	8.00	10.10	3.75	.188

Average height of flame, 10.73 inches.

Average duration of flame, 0.192 millisecond.

IMPACT TEST.

Date, December 28, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	15	1	Explosion.
18	1	Do.	14	3	No explosion.
16	1	No explosion.	14	1	Explosion.
17	1	Explosion.	13	5	No explosion.
16	1	Do.			

The maximum height at which no explosion occurs established at 13 centimeters (5.12 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 168 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Jan. 19	4	Did not explode.	Jan. 19	1	Exploded.
Do	3	Do.	Do	2	Did not explode.
Do	2	Do.	Do	2	Do.

The minimum distance at which no explosion occurs established at 2 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Nov. 22	217	1.02	20.00	62.50	A	61.98
Do	217	1.02	20.00	62.50	A	
Do	217	1.02	19.50	60.94	A	
Nov. 23	217	1.02	19.50	60.94	B	59.90
Do	217	1.02	18.75	58.59	B	
Nov. 24	217	1.02	19.25	60.16	B	
Do	217	1.02	18.50	57.81	C	56.51
Do	217	1.02	18.00	56.25	C	
Do	217	1.02	17.75	55.47	C	

[a] Including 17 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=68.66$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.02$. $W=217$ grams.

$M=\frac{VPS}{W}=4{,}841$ kilograms per square centimeter (68,860 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 17 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, July 13, 1911.	Grams.
Solid	80. 9
Liquid (water)	8. 2
Gaseous	123. 0

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 108.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°*C.*	*Calories.*
Jan. 25	81. 95	0. 809	689. 2
Do	81. 95	. 789	672. 0
Do	81. 95	. 788	671. 2

[a] Including 8.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 677.5.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Nov. 21	63. 50	53. 50	10. 00
Do	63. 25	53. 50	9. 75
Do	63. 50	53. 75	9. 75

Average compression, 9.8 millimeters (0.39 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Sept. 13	63	196	133	15
Do	63	199	136	15
Do	63	200	137	15

Average expansion of bore hole, 135 cubic centimeters (8.24 cubic inches).

FUEL-ITE NO. 3.

Explosive, Fuel-ite No. 3.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Burton Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 145 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 0.91.
  Color of explosive, corn.
  Consistency, fibrous, fine, dry, very soft, slightly cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, June 19, 1911.
  Unit swing on this date, 2.98 inches.
  Weight of charge, in grams, 225, 225, 225.
  Swing, in inches, 3.05, 3.17, 3.14.
  Average swing, in inches, 3.12.

$$3.12 : 2.98 :: 225 : (215).$$

Therefore the unit deflective charge of Fuel-ite No. 3 is 215 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.	Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
June 23	215	8.05	No ignition.	June 26	215	....	No ignition.
Do	215	8.05	Do.	Do	215	....	Do.
Do	215	8.02	Do.	Do	215	....	Do.
Do	215	8.25	Do.	Do	215	....	Do.
Do	215	8.00	Do.	Do	215	....	Do.
Do	215	7.82	Do.	Do	215	....	Do.
Do	215	8.07	Do.	Do	215	....	Do.
Do	215	8.14	Do.				
Do	215	7.94	Do.	TEST 4.			
Do	215	7.85	Do.				
				June 29	[a] 680	3.88	No ignition.
TEST 3.				Do	[a] 680	3.84	Do.
				Do	[a] 680	3.81	Do.
June 26	215	....	No ignition.	Do	[a] 680	4.12	Do.
Do	215	....	Do.	Do	[a] 680	3.87	Do.
Do	215	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
June 19	16.83	43.50	2,585
Do	16.65	43.50	2,613
Do	16.35	43.50	2,661

Average rate of detonation, 2,620 meters (8,590 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Jan. 2	14.00	17.68	5.25	0.262
Do	18.25	23.05	7.00	.350
Do	18.75	23.68	7.00	.350

Average height of flame, 21.47 inches.
Average duration of flame, 0.321 millisecond.

IMPACT TEST.

Date, January 10, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	No explosion.	23	1	Explosion.
30	1	Explosion.	22	5	No explosion.
25	1	Do.			

The maximum height at which no explosion occurs established at 22 centimeters (8.66 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 146 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Feb. 8	2	Did not explode.	Feb. 8	2	Did not explode.
Do	1	Exploded.	Do	2	Do.

The minimum distance at which no explosion occurs established at 2 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Nov. 29	220	0.91	31.25	97.64	A	96.09
Do	220	.91	31.00	96.87	A	
Do	220	.91	30.00	93.75	A	
Dec. 1	220	.91	29.50	92.19	B	91.93
Do	220	.91	29.75	92.97	B	
Do	220	.91	29.00	90.63	B	
Do	220	.91	28.00	87.50	C	86.98
Do	220	.91	27.50	85.93	C	
Dec. 2	220	.91	28.00	87.50	C	

[a] Including 20 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=104.66$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=0.91$. $W=220$ grams.

$M=\frac{VPS}{W}=6{,}630$ kilograms per square centimeter (94,310 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 20 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, July 14, 1911.	Grams.
Solid	16.3
Liquid (water)	64.0
Gaseous	130.0

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 110.0 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°*C.*	*Calories.*
Jan. 25	81.95	1.203	1,014.7
Jan. 26	81.95	1.210	1,020.7
Do	81.95	1.187	1,001.1

[a] Including 10 grams of the original wrapper.

Average large calories per kilogram of explosive, 1,012.2.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Nov. 21	63.50	50.25	13.25
Do	63.50	50.00	13.50
Nov. 28	63.50	50.25	13.25

Average compression, 13.3 millimeters (0.52 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Jan. 16	62	346	284	18
Do	62	338	276	20
Do	62	348	286	16

Average expansion of bore hole, 282 cubic centimeters (17.20 cubic inches).

GIANT A LOW-FLAME DYNAMITE.

Explosive, Giant A low-flame dynamite.
Class 2, hydrated.
Manufactured by the Giant Powder Co. (Consolidated).
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 216 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.27.
  Color of explosive, corn.
  Consistency, granular, coarse, wet, hard, moderately cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, July 1, 1909.
  Unit swing on this date, 2.89 inches.
  Weight of charge, in grams, 350, 350, 350.
  Swing, in inches, 3.04, 3.02, 2.94.
  Average swing, in inches, 3.00.

3.00 : 2.89 : : 350 : (337).

Therefore the unit deflective charge of Giant A low-flame dynamite is 337 grams.

GAS AND DUST GALLERY NO. 1.

Date (1909).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
July 1	337	8.11	No ignition.
Do	337	8.11	Do.
Do	337	8.06	Do.
July 2	337	8.11	Do.
Do	337	8.22	Do.
Do	337	8.22	Do.
Do	337	7.97	Do.
Do	337	8.06	Do.
Do	337	8.06	Do.
Do	337	8.06	Do.
TEST 3.			
July 3	337	....	No ignition.
Do	337	....	Do.
Do	337	....	Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
July 3	337	....	No ignition.
Do	337	....	Do.
Do	337	....	Do.
Do	337	....	Do.
July 6	337	....	Do.
Do	337	....	Do.
Do	337	....	Do.
TEST 4.			
July 1	[a] 680	3.95	No ignition.
Do	[a] 680	4.02	Do.
Do	[a] 680	3.95	Do.
Do	[a] 680	4.02	Do.
Do	[a] 680	4.11	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1909).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Aug. 25	17.30	43	2,486
Aug. 26	17.31	43	2,484
Sept. 1	17.38	43	2,474

Average rate of detonation, 2,481 meters (8,140 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 30	15.25	19.26	8.50	0.425
Do	14.50	18.32	6.25	.312
Do	16.50	20.84	9.25	.462

Average height of flame, 19.47 inches.

Average duration of flame, 0.400 millisecond.

IMPACT TEST.

Date, May 2, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
10	1	No explosion.	18	1	No explosion.
20	1	Explosion.	19	5	Do.

The maximum height at which no explosion occurs established at 19 centimeters (7.48 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 214 grams.

Date (1913).	Distance separating cartridges.	Result, upper cartridge.	Date (1913).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Jan. 31	6	Did not explode.	Feb. 12	9	Exploded.
Do	4	Do.	Do	14	Did not explode.
Do	3	Exploded.	Do	11	Exploded.
Do	4	Do.	Do	13	Did not explode.
Do	5	Do.	Do	12	Do.
Do	6	Do.	Do	12	Exploded.
Do	7	Do.	Do	13	Did not explode.
Feb. 12	8	Do.	Do	13	Do.

The minimum distance at which no explosion occurs extablished at 13 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 5	214	1.33	19.25	60.16	A	61.46
Feb. 6	214	1.33	19.75	61.72	A	
Do	214	1.33	20.00	62.50	A	
Feb. 5	214	1.33	18.75	58.59	B	58.59
Do	214	1.33	18.75	58.59	B	
Do	214	1.33	18.75	58.59	B	
Do	214	1.33	19.00	59.38	C	58.59
Do	214	1.33	18.75	58.59	C	
Do	214	1.33	18.50	57.81	C	

[a] Including 14 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=64.07$ kilograms per square centimeter.
$V=15{,}000$ cubic centimeters. $S=1.33$. $W=214$ grams.

$M=\frac{VPS}{W}=5{,}973$ kilograms per square centimeter (84,960 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 14 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, February 7, 1913.

	Grams.
Solid	83.4
Liquid (water)	17.1
Gaseous	95.3

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.0 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*°C.*	*Calories.*
Feb. 3	81.95	0.772	666.5
Do	81.95	.801	691.9
Do	81.95	.764	659.5

[a] Including 7 grams of the original wrapper.

Average large calories per kilogram of explosive, 672.6.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1909).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
July 7	64.00	52.50	11.50
Do	64.00	52.00	12.00
Do	64.00	52.50	11.50

Average compression, 11.7 millimeters (0.46 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCK.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Mar. 19	62	214	152	15
Do	62	210	148	15
Do	62	208	146	15

Average expansion of bore hole, 149 cubic centimeters (9.09 cubic inches).

GIANT B LOW-FLAME DYNAMITE.

Explosive, Giant B low-flame dynamite.
Class 2, hydrated.
Manufactured by the Giant Powder Co. (Consolidated).
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 237 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.35.
  Color of explosive, corn.
  Consistency, granular, coarse, wet, hard, moderately cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, July 1, 1909.
  Unit swing on this date, 2.89.
  Weight of charge, in grams, 350, 350, 350.
  Swing, in inches, 2.77, 2.72, 2.76.
  Average swing, in inches, 2.75.

2.75 : 2.89 : : 350 : (368).

Therefore the unit deflective charge of Giant B low-flame dynamite is 368 grams.

Gas and Dust Gallery No. 1.

Date (1909).	Weight of charge.	Methane and ethane.	Result.	Date (1909).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 6	368	7.97	No ignition.	July 7	368	....	No ignition.
Do	368	8.22	Do.	Do	368	....	Do.
Do	368	8.06	Do.	Do	368	....	Do.
Do	368	7.88	Do.	Do	368	....	Do.
Do	368	7.88	Do.	Do	368	....	Do.
Do	368	7.88	Do.	Do	368	....	Do.
Do	368	7.79	Do.	Do	368	....	Do.
Do	368	7.96	Do.				
Do	368	7.94	Do.	TEST 4.			
Do	368	7.79	Do.				
				July 6	[a] 680	3.95	No ignition.
TEST 3.				July 15	[a] 680	4.25	Do.
				Do	[a] 680	4.00	Do.
July 7	368	....	No ignition.	Do	[a] 680	4.00	Do.
Do	368	....	Do.	Do	[a] 680	4.17	Do.
Do	368	....	Do.				

[a] 680 grams or more was used.

Rate of Detonation.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1909).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Aug. 26	15.47	43.0	2,780
Do	15.48	43.0	2,778
Sept. 2	15.57	43.0	2,762

Average rate of detonation, 2,773 meters (9,100 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 29	16.00	20.21	7.50	0.375
Do	13.50	17.05	8.25	.412
Do	18.50	23.37	9.75	.488

Average height of flame, 20.21 inches.

Average duration of flame, 0.425 millisecond.

IMPACT TEST.

Date, May 2, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	No explosion.	28	1	No explosion.
30	1	Explosion.	29	5	Do.
25	1	No explosion.			

The maximum height at which no explosion occurs established at 29 centimeters (11.42 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 224 grams.

Date (1913).	Distance separating cartridges.	Result, upper cartridge.	Date (1913).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Jan. 31	6	Exploded.	Feb. 1	16	Exploded.
Do	10	Do.	Feb. 11	17	Did not explode.
Do	14	Do.	Do	17	Exploded.
Do	18	Did not explode.	Do	18	Did not explode.
Feb. 1	16	Do.	Do	18	Do.
Do	15	Exploded.			

The minimum distance at which no explosion occurs established at 18 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 6	213	1.39	17.75	55.47	A	55.99
Do	213	1.39	18.25	57.03	A	
Do	213	1.39	17.75	55.47	A	
Do	213	1.39	16.25	50.78	B	50.52
Do	213	1.39	16.00	50.00	B	
Feb. 7	213	1.39	16.25	50.78	B	
Do	213	1.39	15.75	49.22	C	49.22
Do	213	1.39	15.75	49.22	C	
Do	213	1.39	15.75	49.22	C	

[a] Including 13 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=62.81$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.39$. $W=213$ grams.

$M=\frac{VPS}{W}=6{,}148$ kilograms per square centimeter (87,440 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 13 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst A. L. Hyde.]

Date, February 10, 1913.	Grams.
Solid	61. 8
Liquid (water)	36. 1
Gaseous	91. 5

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1909).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
July 7	64. 00	51. 80	12. 20
Do	64. 00	52. 00	12. 00
Do	64. 00	52. 00	12. 00

Average compression, 12.1 millimeters (0.48 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Mar. 19	62	200	138	15
Do	62	204	142	15
Do	62	200	138	15

Average expansion of bore hole, 139 cubic centimeters (8.48 cubic inches).

GIANT C LOW-FLAME DYNAMITE.

Explosive, Giant C low-flame dynamite.
Class 2, hydrated.
Manufactured by the Giant Powder Co. (Consolidated).
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 274 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.55.
  Color of explosive, drab.
  Consistency, granular, coarse, wet, soft, moderately cohesive.

Unit deflective charge as determined by the ballistic pendulum:
Date, July 2, 1909.
Unit swing on this date, 2.89.
Weight of charge, in grams, 310, 310, 310.
Swing, in inches, 3.04, 2.94, 2.99.
Average swing, in inches, 2.99.

$$2.99 : 2.89 : : 310 : (300).$$

Therefore the unit deflective charge of Giant C low-flame dynamite is 300 grams.

GAS AND DUST GALLERY No. 1.

Date (1909).	Weight of charge.	Methane and ethane.	Result.	Date (1909).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 8	300	7.96	No ignition.	July 8	300	....	No ignition.
Do	300	8.13	Do.	Do	300	....	Do.
Do	300	7.96	Do	Do	300	....	Do.
Do	300	7.96	Do.	Do	300	....	Do.
Do	300	8.13	Do.	July 9	300	....	Do.
Do	300	8.30	Do.	Do	300	....	Do.
Do	300	7.96	Do.	Do	300	....	Do.
Do	300	7.79	Do.				
Do	300	8.13	Do.	TEST 4.			
Do	300	7.96	Do.				
				July 8	[a]680	3.97	No ignition.
TEST 3.				July 15	[a]680	4.17	Do.
				Do	[a]680	4.17	Do.
July 8	300	....	No ignition.	July 16	[a]680	4.17	Do.
Do	300	....	Do.	Do	[a]680	4.09	Do.
Do	300	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1909).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Aug. 26	15.55	43.0	2,765
Aug. 27	16.05	43.0	2,679
Oct. 9	16.15	43.0	2,663

Average rate of detonation, 2,702 meters (8,860 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 29	18.50	23.37	9.50	0.475
Do	22.00	27.79	9.75	.488
Do	20.25	25.58	10.25	.512

Average height of flame, 25.58 inches.
Average duration of flame, 0.492 millisecond.

IMPACT TEST.

Date, May 3, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
28	1	No explosion.	32	1	Explosion.
30	1	Do.	31	1	Do.
34	1	Explosion.	30	1	Do.
32	1	No explosion.	28	1	Do.
33	1	Explosion.	27	1	Do.
32	1	No explosion.	26	5	No explosion.

The maximum height at which no explosion occurs established at 26 centimeters (10.24 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 240 grams.

Date (1913).	Distance separating cartridges.	Result, upper cartridge.	Date (1913).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Feb. 12	15	Exploded.	Feb. 12	20	Did not explode
Do	17	Do.	Do	20	Do.
Do	19	Do.	Do	20	Do.
Do	21	Did not explode.			

The minimum distance at which no explosion occurs established at 20 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 6	212	1.49	21.75	67.97	A	66.93
Do	212	1.49	21.00	65.62	A	
Do	212	1.49	21.50	67.19	A	
Feb. 7	212	1.49	20.75	64.84	B	63.80
Do	212	1.49	20.00	62.50	B	
Do	212	1.49	20.50	64.06	B	
Do	212	1.49	19.00	59.38	C	59.64
Do	212	1.49	19.00	59.38	C	
Feb. 8	212	1.49	19.25	60.16	C	

[a] Including 12 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=75.65$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=1.49$. $W=212$ grams.

$M=\frac{VPS}{W}=7,975$ kilograms per square centimeter (113,430 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 12 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, February 11, 1913.

	Grams.
Solid	64.6
Liquid (water)	23.2
Gaseous	94.7

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.0 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Feb. 5	81.95	0.947	827.2
Do	81.95	.955	834.2
Do	81.95	.913	797.3

[a] Including 6 grams of the original wrapper.

Average large calories per kilogram of explosive, 819.6.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1909).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
July 7	64.00	49.30	14.70
Do	64.00	49.80	14.20
Do	64.00	49.10	14.90

Average compression, 14.6 millimeters (0.57 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
May 26	63	174	111	15
Do	63	177	114	15
Do	63	172	109	15

Average expansion of bore hole, 111 cubic centimeters (6.77 cubic inches).

GIANT COAL-MINE POWDER NO. 5.

Explosive, Giant coal-mine powder No. 5.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Giant Powder Co. (Consolidated).
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 157 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 0.89.
  Color of explosive, corn.
  Consistency, granular and fibrous, mostly very fine with large white crystals, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, September 12, 1911.
Unit swing on this date, 3.23 inches.
Weight of charge, in grams, 230, 230, 230.
Swing, in inches, 3.25, 3.22, 3.32.
Average swing, in inches, 3.26.

3.26 : 3.23 : : 230 : (228).

Therefore the unit deflective charge of Giant coal-mine powder No. 5 is 228 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Sept. 15	228	8.16	No ignition.
Do	228	8.27	Do.
Do	228	8.11	Do.
Sept. 16	228	8.19	Do.
Do	228	8.19	Do.
Do	228	8.31	Do.
Do	228	8.33	Do.
Sept. 18	228	7.97	Do.
Do	228	8.08	Do.
Do	228	7.90	Do.
TEST 3.			
Oct. 5	228	....	No ignition.
Do	228	....	Do.
Do	228	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Oct. 5	228	....	No ignition.
Do	228	....	Do.
Do	228	....	Do.
Do	228	....	Do.
Do	228	....	Do.
Do	228	....	Do.
Do	228	....	Do.
TEST 4.			
Sept. 13	[a] 680	4.19	No ignition.
Do	[a] 680	4.26	Do.
Sept. 15	[a] 680	4.06	Do.
Sept. 18	[a] 680	4.26	Do.
Do	[a] 680	4.23	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Sept. 13	14.70	45.0	3,061
Sept. 14	14.10	45.0	3,191
Sept. 18	14.50	45.0	3,103

Average rate of detonation, 3,118 meters (10,230 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Feb. 20	16.50	20.84	6.50	0.325
Do	19.50	24.63	8.00	.400
Do	19.50	24.63	8.75	.438

Average height of flame, 23.37 inches.
Average duration of flame, 0.388 millisecond.

IMPACT TEST.

Date, January 11, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
24	1	Explosion.	15	1	Explosion.
16	1	No explosion.	14	1	No explosion.
20	1	Explosion.	14	1	Explosion.
18	1	Do.	13	2	No explosion.
16	1	No explosion.	13	1	Explosion.
16	1	Explosion.	12	5	No explosion.

The maximum height at which no explosion occurs established at 12 centimeters (4.72 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 147 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Feb. 28	2	Did not explode.	Feb. 28	2	Did not explode.
Do	1	Exploded.	Do	2	Do.

The minimum distance at which no explosion occurs established at 2 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 9	217	0.89	30.00	93.75	A	94.27
Do	217	.89	30.00	93.75	A	
Feb. 10	217	.89	30.50	95.31	A	
Feb. 2	217	.89	30.50	95.31	B	97.14
Do	217	.89	31.75	99.22	B	
Feb. 5	217	.89	31.00	96.88	B	
Do	217	.89	26.75	83.59	C	82.81
Do	217	.89	26.25	82.03	C	
Feb. 6	217	.89	26.50	82.81	C	

[a] Including 17 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=111.88$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=0.89$. $W=217$ grams.

$M=\frac{VPS}{W}=6{,}883$ kilograms per square centimeter (97,910 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 17 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, November 15, 1911.	Grams.
Solid	2.4
Liquid (water)	65.5
Gaseous	140.9

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 108.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*°C.*	*Calories.*
Feb. 2	81.95	1.098	939.1
Do	81.95	1.102	942.6
Feb. 5	81.95	1.103	943.5

[a] Including 8.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 941.7.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Feb. 12	63.50	49.75	13.75
Do	63.50	50.00	13.50
Do	63.50	50.25	13.25

Average compression, 13.5 millimeters (0.53 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Feb. 20	62	340	278	15
Do	62	332	270	15
Do	62	345	283	15

Average expansion of bore hole, 277 cubic centimeters (16.90 cubic inches).

GIANT COAL-MINE POWDER NO. 6.

Explosive, Giant coal-mine powder No. 6.

Class 2, hydrated.

Manufactured by the Giant Powder Co. (Consolidated).

Physical examination:

- Diameter of cartridge, 1¼ inches.
- Length of cartridge, 8 inches.
- Average weight, 201 grams.
- Cartridge had been redipped.
- Apparent specific gravity of cartridge by sand, 1.14.
- Color of explosive, corn.
- Consistency, granular and fibrous, mostly very fine with a few large white crystals, wet, soft, moderately cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, September 12, 1911.
Unit swing on this date, 3.23 inches.
Weight of charge, in grams, 290, 290, 290.
Swing, in inches, 3.40, 3.37, 3.36.
Average swing, in inches, 3.38.

3.38 : 3.23 : : 290 : (277).

Therefore the unit deflective charge of Giant coal-mine powder No. 6 is 277 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.	Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Sept. 21	277	7.93	No ignition.	Oct. 5	277	....	No ignition.
Do	277	7.97	Do.	Do	277	....	Do.
Do	277	7.91	Do.	Do	277	....	Do.
Sept. 23	277	8.27	Do.	Do	277	....	Do.
Do	277	7.91	Do.	Do	277	....	Do.
Do	277	8.01	Do.	Do	277	....	Do.
Do	277	8.17	Do.	Do	277	....	Do.
Sept. 25	277	8.27	Do.				
Do	277	8.14	Do.	TEST 4.			
Do	277	8.01	Do.				
				Sept. 18	[a] 680	4.29	No ignition.
TEST 3.				Sept. 19	[a] 680	4.22	Do.
				Do	[a] 680	4.22	Do.
Oct. 5	277	....	No ignition.	Do	[a] 680	3.86	Do.
Do	277	....	Do.	Sept. 20	[a] 680	3.99	Do.
Do	277	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Sept. 12	12.79	45.0	3,518
Sept. 18	12.99	45.0	3,464
Sept. 19	12.02	43.0	3,577

Average rate of detonation, 3,520 meters (11,550 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Feb. 20	13.25	16.74	5.00	0.250
Do	16.50	20.84	8.00	.400
Do	14.00	17.68	6.75	.338

Average height of flame, 18.42 inches.
Average duration of flame, 0.329 millisecond.

IMPACT TEST.

Date, February 3, 1913.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
70	1	Explosion.	25	1	No explosion.
60	1	Do.	28	1	Explosion.
50	1	Do.	26	1	No explosion.
40	1	Do.	27	1	Explosion.
30	1	Do.	26	1	Do.
20	1	No explosion.	25	4	No explosion.

The maximum height at which no explosion occurs established at 25 centimeters (9.84 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 183 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Feb. 29	3	Did not explode.	Feb. 29	2	Exploded.
Do	2	Do.	Do	3	Did not explode.
Do	1	Exploded.	Do	3	Do.
Do	2	Did not explode.			

The minimum distance at which no explosion occurs established at 3 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 8	215	1.14	24.50	76.56	A	74.48
Do	215	1.14	23.50	73.44	A	
Feb. 9	215	1.14	23.50	73.44	A	
Feb. 8	215	1.14	22.00	68.75	B	69.53
Do	215	1.14	22.25	69.53	B	
Do	215	1.14	22.50	70.31	B	
Feb. 6	215	1.14	20.00	62.50	C	63.28
Feb. 7	215	1.14	20.50	64.06	C	
Feb. 8	215	1.14	20.25	63.28	C	

[a] Including 15 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=87.81$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.14$. $W=215$ grams.

$M=\frac{VPS}{W}=6{,}984$ kilograms per square centimeter (99,340 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 15 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, November 16, 1911.

	Grams.
Solid	24.2
Liquid (water)	44.5
Gaseous	130.0

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*°C.*	*Calories.*
Feb. 6	81.95	0.924	794.9
Do	81.95	.913	785.4
Do	81.95	.881	757.5

[a] Including 7.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 779.3.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Feb. 12	63.25	47.50	15.75
Do	63.25	48.25	15.00
Do	63.50	47.75	15.75

Average compression, 15.5 millimeters (0.61 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Feb. 20	62	250	188	15
Do	62	256	194	15
Do	62	259	197	15

Average expansion of bore hole, 193 cubic centimeters (11.77 cubic inches).

GIANT COAL-MINE POWDER NO. 7.

Explosive, Giant coal-mine powder No. 7.
Class 2, hydrated.
Manufactured by the Giant Powder Co. (Consolidated).
Physical examination:
 Diameter of cartridge, 1¼ inches.
 Length of cartridge, 8 inches.
 Average weight, 208 grams.
 Cartridge had been redipped.
 Apparent specific gravity of cartridge by sand, 1.19.
 Color of explosive, corn.
 Consistency, granular and fibrous, mostly very fine with a few large white crystals, wet, soft, moderately cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, September 12, 1911.
Unit swing on this date, 3.23 inches.
Weight of charge, in grams, 245, 245, 245.
Swing, in inches, 3.27, 3.23, 3.19.
Average swing, in inches, 3.23.

3.23 : 3.23 : : 245 : (245).

Therefore the unit deflective charge of Giant coal-mine powder No. 7 is 245 grams.

GAS AND DUST GALLERY No. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Sept. 25	245	8.33	No ignition.
Do	245	8.30	Do.
Do	245	8.20	Do.
Do	245	8.36	Do.
Do	245	8.35	Do.
Do	245	8.18	Do.
Do	245	8.26	Do.
Oct. 3	245	8.20	Do.
Do	245	8.44	Do.
Do	245	7.98	Do.
TEST 3.			
Oct. 4	245		No ignition.
Do	245		Do.
Do	245		Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Oct. 4	245		No ignition.
Do	245		Do.
Do	245		Do.
Do	245		Do.
Do	245		Do.
Do	245		Do.
Do	245		Do.
TEST 4.			
Sept. 19	[a] 680	4.02	No ignition.
Do	[a] 680	4.15	Do.
Do	[a] 680	4.03	Do.
Sept. 20	[a] 680	4.06	Do.
Do	[a] 680	4.03	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Sept. 20	13.30	45.0	3,383
Do	13.74	45.0	3,275
Do	13.87	45.0	3,244

Average rate of detonation, 3,301 meters (10,830 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Feb. 20	6.75	8.53	2.50	0.125
Do	12.25	15.47	4.50	.225
Do	15.50	19.58	8.00	.400

Average height of flame, 14.53 inches.
Average duration of flame, 0.250 millisecond.

IMPACT TEST.

Date, February 4, 1913.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
30	1	No explosion.	38	1	No explosion.
35	1	Do.	39	1	Explosion.
40	1	Explosion.	38	1	Do.
35	1	No explosion.	37	4	No explosion.
37	1	Do.			

The maximum height at which no explosion occurs established at 37 centimeters (14.57 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 191 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Feb. 29	3	Did not explode.	Feb. 29	3	Did not explode.
Do	2	Exploded.	Do	3	Do.

The minimum distance at which no explosion occurs established at 3 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 28	215.6	1.19	21.00	65.62	A	67.45
Do	215.6	1.19	21.75	67.97	A	
Do	215.6	1.19	22.00	68.75	A	
Feb. 23	215.6	1.19	19.50	60.94	B	59.90
Do	215.6	1.19	19.00	59.38	B	
Do	215.6	1.19	19.00	59.38	B	
Do	215.6	1.19	19.00	59.38	C	59.90
Do	215.6	1.19	18.75	58.59	C	
Do	215.6	1.19	19.75	61.72	C	

[a] Including 15.6 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=74.33$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.19$. $W=215.6$ grams.

$M=\frac{VPS}{W}=6{,}154$ kilograms per square centimeter (87,540 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 16 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, November 17, 1911.	Grams.
Solid	33.3
Liquid (water)	48.5
Gaseous	126.3

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.8 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms	*°C.*	*Calories.*
Feb. 7	81.95	0.991	851.6
Do	81.95	.997	856.8
Do	81.95	.978	840.2

[a] Including 7.8 grams of the original wrapper.

Average large calories per kilogram of explosive, 849.5.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1913).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Jan. 28	63.50	50.00	13.50
Do	63.00	49.50	13.50
Jan. 29	63.00	49.50	13.50

Average compression, 13.5 millimeters (0.53 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Feb. 20	62	244	182	15
Do	62	248	186	15
Do	62	253	191	15

Average expansion of bore hole, 186 cubic centimeters (11.35 cubic inches).

GIANT COAL-MINE POWDER NO. 8.

Explosive, Giant coal-mine powder No. 8.

Class 2, hydrated.

Manufactured by the Giant Powder Co. (Consolidated).

Physical examination:

- Diameter of cartridge, 1¼ inches.
- Length of cartridge, 8 inches.
- Average weight, 231 grams.
- Cartridge had been redipped.
- Apparent specific gravity of cartridge by sand, 1.29.
- Color of explosive, corn.
- Consistency, granular and fibrous, mostly very fine with a few large white crystals, wet, soft, moderately cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, September 12, 1911.

Unit swing on this date, 3.23 inches.

Weight of charge, in grams, 245, 245, 245.

Swing, in inches, 3.19, 3.24, 3.19.

Average swing, in inches, 3.21.

3.21 : 3.23 : : 245 : (247).

Therefore the unit deflective charge of Giant coal-mine powder No. 8 is 247 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.	Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*		TEST 3—Con.	*Grams.*	*Per cent.*	
Oct. 3	247	7.95	No ignition.	Oct. 4	247	....	No ignition.
Do	247	8.18	Do.	Do	247	....	Do.
Do	247	8.12	Do.	Do	247	....	Do.
Do	247	8.39	Do.	Do	247	....	Do.
Do	247	8.00	Do.	Do	247	....	Do.
Do	247	8.01	Do.	Do	247	....	Do.
Do	247	7.92	Do.	Do	247	....	Do.
Do	247	8.09	Do.	TEST 4.			
Do	247	8.23	Do.	Sept. 20	[a] 680	4.13	No ignition.
Oct. 4	247	8.08	Do.	Do	[a] 680	4.24	Do.
TEST 3.				Do	[a] 680	4.20	Do.
Oct. 4	247	....	No ignition.	Do	[a] 680	4.26	Do.
Do	247	....	Do.	Do	[a] 680	3.98	Do.
Do	247	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.

Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Sept. 12	13.47	45.0	3,341
Sept. 19	13.40	45.0	3,358
Do	14.05	45.0	3,203

Average rate of detonation, 3,301 meters (10,830 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Feb. 9	17.25	21.79	7.50	0.375
Do	12.00	15.16	4.75	.238
Do	11.50	14.53	5.50	.225

Average height of flame, 17.16 inches.

Average duration of flame, 0.279 millisecond.

IMPACT TEST.

Date, February 4, 1913.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
30	1	No explosion.	36	3	No explosion.
35	1	Do.	36	1	Explosion.
40	1	Explosion.	35	1	Do.
38	1	Do.	34	5	No explosion.
37	1	Do.			

The maximum height at which no explosion occurs established at 34 centimeters (13.39 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 207 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Feb. 29	3	Did not explode.	Feb. 29	2	Did not explode.
Do	2	Do.	Do	2	Do.
Do	1	Exploded.			

The minimum distance at which no explosion occurs established at 2 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 10	214.2	1.29	24.75	77.34	A	76.04
Do	214.2	1.29	24.50	76.56	A	
Feb. 12	214.2	1.29	23.75	74.22	A	
Do	214.2	1.29	21.75	67.97	B	69.53
Do	214.2	1.29	22.75	71.09	B	
Do	214.2	1.29	22.25	69.53	B	
Do	214.2	1.29	22.75	71.09	C	69.53
Do	214.2	1.29	22.25	69.53	C	
Feb. 13	214.2	1.29	21.75	67.97	C	

[a] Including 14.2 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=81.97$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.29$. $W=214.2$ grams.

$M=\frac{VPS}{W}=7{,}405$ kilograms per square centimeter (105,330 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 14 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, November 21, 1911.	Grams.
Solid	31.4
Liquid (water)	48.5
Gaseous	119.0

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.1 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	° *C.*	*Calories.*
Feb. 8	81.95	0.959	829.2
Do	81.95	.985	851.9
Do	81.95	.983	850.1

[a] Including 7.1 grams of the original wrapper.

Average large calories per kilogram of explosive, 843.7.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1913).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Jan. 29	63.50	51.50	12.00
Do	63.25	50.75	12.50
Do	63.50	51.00	12.50

Average compression, 12.3 millimeters (0.48 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	° *C.*
Feb. 20	62	260	198	15
Do	62	266	204	15
Do	62	257	195	15

Average expansion of bore hole, 199 cubic centimeters (12.14 cubic inches)

GUARDIAN A.

Explosive, Guardian A.
Class 4, nitroglycerin.
Manufactured by the Independent Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 176 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 1.04.
  Color of explosive, corn.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by ballistic pendulum:

Date, September 30, 1912.
Unit swing on this date, 3.24 inches.
Weight of charge, in grams, 290, 290, 290.
Swing, in inches, 3.22, 3.13, 3.15.
Average swing, in inches, 3.17.

$$3.17 : 3.24 :: 290 : (296).$$

Therefore the unit deflective charge of Guardian A is 296 grams.

GAS AND DUST GALLERY NO. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Oct. 1	296	8.21	No ignition.
Oct. 2	296	8.34	Do.
Do	296	8.51	Do.
Do	296	8.25	Do.
Do	296	8.23	Do.
Do	296	8.20	Do.
Do	296	7.89	Do.
Do	296	8.50	Do.
Do	296	8.35	Do.
Do	296	7.92	Do.
TEST 3.			
Oct. 3	296	....	No ignition.
Do	296	....	Do.
Do	296	....	Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Oct. 3	296	....	No ignition.
Do	296	....	Do.
Do	296	....	Do.
Do	296	....	Do.
Do	296	....	Do.
Do	296	....	Do.
Do	296	....	Do.
TEST 4.			
Oct. 2	[a] 680	4.31	No ignition.
Oct. 3	[a] 680	4.11	Do.
Do	[a] 680	4.10	Do.
Do	[a] 680	4.25	Do.
Do	[a] 680	4.12	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Oct. 2	13.95	43.5	3,119
Do	14.20	43.5	3,063
Do	14.10	43.5	3,085

Average rate of detonation, 3,089 meters (10,130 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 20	11.00	13.89	4.25	0.212
Do	12.25	15.47	5.50	.275
Do	11.75	14.84	5.00	.250

Average height of flame, 14.73 inches.
Average duration of flame, 0.246 millisecond.

IMPACT TEST.

Date, October 18, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
15	1	No explosion.	31	1	Explosion.
25	1	Do.	30	2	No explosion.
35	1	Do.	30	1	Explosion.
45	1	Explosion.	28	1	Do.
40	1	Do.	26	1	Do.
37	1	Do.	25	1	Do.
36	1	Do.	20	1	Do.
35	1	Do.	18	1	No explosion.
30	1	No explosion.	19	5	Do.
33	1	Explosion.			

The maximum height at which no explosion occurs established at 19 centimeters (7.48 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 167 grams.

Date (1913).	Distance separating cartridges.	Result, upper cartridge.	Date (1913).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Mar. 20	7	Exploded.	Mar. 20	8	Did not explode.
Do	8	Did not explode.	Do	8	Do.

The minimum distance at which no explosion occurs established at 8 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Oct. 23	219	1.04	22.50	70.31	A	68.49
Do	219	1.04	21.75	67.97	A	
Do	219	1.04	21.50	67.19	A	
Oct. 24	219	1.04	20.50	64.06	B	64.58
Do	219	1.04	20.75	64.84	B	
Do	219	1.04	20.75	64.84	B	
Oct. 25	219	1.04	19.00	59.38	C	60.42
Do	219	1.04	19.75	61.72	C	
Do	219	1.04	19.25	60.16	C	

[a] Including 19 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=77.92$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.04$. $W=219$ grams.

$$M=\frac{VPS}{W}=5{,}550$$ kilograms per square centimeter (78,940 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 19 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, October 3, 1912.

	Grams.
Solid	82.1
Liquid (water)	25.3
Gaseous	92.8

Large Calories Developed by 1 Kilogram of the Explosive.

Charge, 109.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°*C.*	*Calories.*
Oct. 11	81.95	0.885	747.9
Oct. 14	81.95	.904	764.0
Oct. 16	81.95	.909	768.3

[a] Including 9.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 760.1.

Compression of Small Lead Blocks.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Oct. 23	63.25	50.50	12.75
Do	63.50	51.25	12.25
Oct. 24	63.25	50.75	12.50

Average compression, 12.5 millimeters (0.49 inch).

Expansion of Bore Hole of Trauzl Lead Blocks.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Oct. 17	62	212	150	15
Do	62	218	156	15
Do	62	219	157	15

Average expansion of bore hole, 154 cubic centimeters (9.39 cubic inches).

GUARDIAN NO. 2.

Explosive, Guardian No. 2.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the Independent Powder Co.
Physical examination:
  Diameter of cartridge, $1\frac{1}{4}$ inches.
  Length of cartridge, 8 inches.
  Average weight, 168 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 1.02.
  Color of explosive, straw.
  Consistency, powdered, very fine, very dry, very soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, December 4, 1911.

Unit swing on this date, 3.40 inches.

Weight of charge, in grams, 250, 250, 250.

Swing, in inches, 3.48, 3.52, 3.41.

Average swing, in inches, 3.47.

3.47 : 3.40 : : 250 : (245).

Therefore the unit deflective charge of Guardian No. 2 is 245 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.	Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Dec. 6	245	8.46	No ignition.	Dec. 14	245	....	No ignition.
Dec. 7	245	8.05	Do.	Dec. 15	245	....	Do.
Do	245	8.24	Do.	Do	245	....	Do.
Do	245	8.08	Do.	Do	245	....	Do.
Do	245	8.24	Do.	Do	245	....	Do.
Do	245	8.35	Do.	Do	245	....	Do.
Do	245	8.35	Do.	Do	245	....	Do.
Do	245	8.40	Do.				
Do	245	8.34	Do.	TEST 4.			
Do	245	8.48	Do.				
				Dec. 11	[a] 680	3.81	No ignition.
TEST 3.				Do	[a] 680	4.19	Do.
				Do	[a] 680	4.20	Do.
Dec. 14	245	....	No ignition.	Do	[a] 680	4.02	Do.
Do	245	....	Do.	Do	[a] 680	4.15	Do.
Do	245	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.

Electric detonator, No. 7.

Date (1911-12).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Dec. 30	16.10	44.5	2,764
Jan. 3	16.65	45.0	2,703
Do	16.20	44.5	2,747

Average rate of detonation, 2,738 meters (8,980 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 8	13.50	17.05	9.00	0.450
Do	14.75	18.63	5.75	.288
Do	15.75	19.89	6.00	.300

Average height of flame, 18.52 inches.

Average duration of flame, 0.346 millisecond.

Impact Test.

Date, February 26, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
15	1	No explosion.	15	1	Explosion.
18	1	Explosion.	14	1	Do.
17	1	No explosion.	13	2	No explosion.
17	1	Explosion.	13	1	Explosion.
16	1	Do.	12	1	Do.
15	1	No explosion.	11	5	No explosion.

The maximum height at which no explosion occurs established at 11 centimeters (4.33 inches).

Explosion-by-Influence Test.

Weight of each cartridge, 164 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Apr. 2	3	Did not explode.	Apr. 3	4	Exploded.
Do	2	Do.	Do	5	Do.
Do	1	Exploded.	Do	6	Did not explode.
Do	2	Do.	Do	6	Do.
Do	3	Did not explode.	Do	6	Do.
Do	3	Exploded.			

The minimum distance at which no explosion occurs established at 6 inches.

Theoretical Maximum Pressure Developed in Own Volume, as Determined by Bichel Pressure Gage.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Mar. 11	215	1.02	30.00	93.75	A	94.27
Do	215	1.02	30.75	96.09	A	
Do	215	1.02	29.75	92.97	A	
Mar. 20	215	1.02	28.75	89.84	B	90.10
Mar. 27	215	1.02	29.00	90.62	B	
Do	215	1.02	28.75	89.84	B	
Mar. 13	215	1.02	28.25	88.28	C	89.06
Mar. 12	215	1.02	28.75	89.84	C	
Mar. 20	215	1.02	28.50	89.06	C	

[a] Including 15 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=99.54$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.02$. $W=215$ grams.

$M=\frac{VPS}{W}=7{,}084$ kilograms per square centimeter (100,760 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 15 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, December 8, 1911.

	Grams.
Solid	33.1
Liquid (water)	63.0
Gaseous	106.3

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Feb. 21	81.95	1.228	1,060.1
Do	81.95	1.237	1,067.9
Do	81.95	1.221	1,054.0

[a] Including 7.5 grams of original wrapper.

Average large calories per kilogram of explosive, 1,060.7.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 28	63.50	49.75	13.75
Do	63.50	49.75	13.75
Do	63.50	50.00	13.50

Average compression, 13.7 millimeters (0.54 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Mar. 28	63	290	227	20
Do	63	290	227	20
Do	63	279	216	20

Average expansion of bore hole, 223 cubic centimeters (13.60 cubic inches)

GUARDIAN NO. 3.

Explosive, Guardian No. 3.
Class 1*a*, ammonium nitrate, containing nitroglycerin
Manufactured by the Independent Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 150 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 0.92.
  Color of explosive, straw.
  Consistency, powdered, very fine, very dry, very soft, not cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, December 4, 1911.
  Unit swing on this date, 3.40 inches.
  Weight of charge, in grams, 270, 270, 270.
  Swing, in inches, 3.36, 3.32, 3.45.
  Average swing, in inches, 3.38.

$$3.38 : 3.40 :: 270 : (272).$$

Therefore the unit deflective charge of Guardian No. 3 is 272 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Dec. 7	272	8.49	No ignition.
Do	272	8.46	Do.
Do	272	8.30	Do.
Dec. 8	272	8.25	Do.
Do	272	7.92	Do.
Do	272	8.01	Do.
Do	272	8.08	Do.
Do	272	8.27	Do.
Do	272	8.23	Do.
Do	272	8.29	Do.
TEST 3.			
Dec. 15	272	....	No ignition.
Do	272	....	Do.
Do	272	....	Do.
TEST 3—Con.			
Dec. 15	272	....	No ignition.
Do	272	....	Do.
Do	272	....	Do.
Do	272	....	Do.
Do	272	....	Do.
Do	272	....	Do.
Do	272	....	Do.
TEST 4.			
Dec. 8	[a] 680	4.41	No ignition.
Do	[a] 680	4.41	Do.
Do	[a] 680	4.43	Do.
Dec. 11	[a] 680	3.92	Do.
Dec. 12	[a] 680	4.13	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911-12).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Dec. 30	18.90	44.0	2,328
Jan. 3	19.35	44.5	2,300
Jan. 4	18.70	44.5	2,380

Average rate of detonation, 2,336 meters (7,660 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 8	14.25	18.00	4.50	0.225
Do	13.75	17.37	4.00	.200
Do	13.00	16.42	6.00	.300

Average height of flame, 17.26 inches.

Average duration of flame, 0.242 millisecond.

IMPACT TEST.

Date, February 23, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	No explosion.	22	1	Explosion.
25	1	Explosion.	21	1	Do.
24	1	Do.	20	1	Do.
23	1	Do.	15	1	Do.
22	1	No explosion.	14	5	No explosion.

The maximum height at which no explosion occurs established at 14 centimeters (5.51 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 148 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Apr. 15	5	Did not explode.	Apr. 23	4	Did not explode.
Apr. 17	4	Do.	Do	4	Exploded.
Do	3	Do.	Do	5	Did not explode.
Do	2	Exploded.	Do	5	Do.
Do	3	Do.			

The minimum distance at which no explosion occurs established at 5 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Mar. 29	219	0.92	26.25	82.03	A	82.29
Do	219	.92	26.00	81.25	A	
Do	219	.92	26.75	83.59	A	
Mar. 27	219	.92	24.50	76.56	B	78.39
Do	219	.92	25.50	79.69	B	
Do	219	.92	25.25	78.91	B	
Do	219	.92	26.25	82.03	C	82.29
Mar. 28	219	.92	26.25	82.03	C	
Do	219	.92	26.50	82.81	C	

[a] Including 19 grams of the original wrapper.

$P = 1.911A + 0.5B - 1.411C = 80.34$ kilograms per square centimeter.

$V = 15{,}000$ cubic centimeters. $S = 0.92$. $W = 219$ grams.

$M = \frac{VPS}{W} = 5{,}063$ kilograms per square centimeter (72,010 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 26 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, December 11, 1911.	Grams.
Solid	48.3
Liquid (water)	50.0
Gaseous	113.9

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 113.0 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°C.	*Calories.*
Feb. 23	81.95	1.060	869.5
Feb. 26	81.95	1.086	890.9
Feb. 28	81.95	1.065	873.6

[a] Including 13 grams of the original wrapper.

Average large calories per kilogram of explosive, 878.0.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 29	63.00	51.25	11.75
Do	63.25	51.00	12.25
Do	63.25	51.50	11.75

Average compression, 11.9 millimeters (0.47 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°C.
Feb. 23	62	263	201	15
Do	62	266	204	15
Do	62	273	211	15

Average expansion of bore hole, 205 cubic centimeters (12.50 cubic inches).

GUARDIAN COAL POWDER B.

Explosive, Guardian coal powder B.
Class 4, nitroglycerin.
Manufactured by the Independent Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 213 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 1.28.
  Color of explosive, corn.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, May 6, 1912.
  Unit swing on this date, 3.39 inches.
  Weight of charge, in grams, 310, 310, 310.
  Swing, in inches, 3.40, 3.38, 3.39.
  Average swing, in inches, 3.39.

3.39 : 3.39 : : 310 : (310).

Therefore the unit deflective charge of Guardian coal powder B is 310 grams.

GAS AND DUST GALLERY NO. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
May 7	310	7.97	No ignition.
Do	310	8.01	Do.
Do	310	8.32	Do.
Do	310	8.22	Do.
Do	310	7.86	Do.
Do	310	8.06	Do.
Do	310	8.44	Do.
Do	310	8.18	Do.
Do	310	8.44	Do.
Do	310	8.12	Do.
TEST 3.			
May 8	310	....	No ignition.
Do	310	....	Do.
Do	310	....	Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
May 8	310	....	No ignition
Do	310	....	Do.
Do	310	....	Do.
Do	310	....	Do.
Do	310	....	Do.
Do	310	....	Do.
Do	310	....	Do.
TEST 4.			
May 7	[a] 680	4.54	No ignition.
Do	[a] 680	4.30	Do.
Do	[a] 680	4.36	Do.
May 8	[a] 680	4.34	Do.
Do	[a] 680	4.37	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
May 7	16.50	44.0	2,667
Do	15.90	44.5	2,799
Do	16.10	44.0	2,733

Average rate of detonation, 2,733 meters (8,960 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 23	10.75	13.58	4.25	0.212
Do	10.50	13.26	4.00	.200
Do	6.75	8.53	2.50	.125

Average height of flame, 11.79 inches.
Average duration of flame, 0.179 millisecond.

IMPACT TEST.

Date, August 20, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
40	1	Explosion.	14	1	No explosion.
30	1	Do.	16	1	Explosion.
20	1	Do.	15	5	No explosion.
10	1	No explosion.			

The maximum height at which no explosion occurs established at 15 centimeters (5.91 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 206 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Sept. 9	2	Did not explode.	Sept. 9	2	Did not explode.
Do	1	Exploded.	Do	2	Do.

The minimum distance at which no explosion occurs established at 2 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Aug. 26	215	1.28	21.50	67.19	A	67.19
Do	215	1.28	21.25	66.41	A	
Do	215	1.28	21.75	67.97	A	
Aug. 24	215	1.28	21.25	66.41	B	64.84
Do	215	1.28	20.75	64.84	B	
Do	215	1.28	20.25	63.28	B	
Aug. 23	215	1.28	20.50	64.06	C	63.54
Do	215	1.28	20.50	64.06	C	
Do	215	1.28	20.00	62.50	C	

[a] Including 15 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=71.17$ kilograms per square centimeter.
$V=15{,}000$ cubic centimeters. $S=1.28$. $W=215$ grams.
$M=\frac{VPS}{W}=6{,}356$ kilograms per square centimeter (90,400 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 15 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, May 14, 1912.

	Grams.
Solid	93.1
Liquid (water)	31.3
Gaseous	75.5

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Aug. 15	63.25	52.75	10.50
Do	63.25	53.25	10.00
Do	62.75	52.75	10.00

Average compression, 10.2 millimeters (0.40 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°C.
Sept. 27	62	168	106	15
Do	62	172	110	15
Do	62	169	107	15

Average expansion of bore hole, 108 cubic centimeters (6.59 cubic inches).

HECLA NO. 2.

Explosive, Hecla No. 2.
Class 1*a*, ammonium nitrate.
Manufactured by the E. I. du Pont de Nemours Powder Co.
Physical examination:
  Diameter of cartridge, 1½ inches.
  Length of cartridge, 8 inches.
  Average weight, 252 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 1.03.
  Color of explosive, straw.
  Consistency, powdered, very fine, dry, hard, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, February 7, 1910.
Unit swing on this date, 2.99 inches.
Weight of charge, in grams, 240, 240, 240.
Swing, in inches, 2.81, 2.82, 2.89.
Average swing, in inches, 2.84.

2.84 : 2.99 : : 240 : (253).

Therefore the unit deflective charge of Hecla No. 2 is 253 grams.

GAS AND DUST GALLERY NO. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.	Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Feb. 11	253	8.33	No ignition.	Feb. 16	253		No ignition.
Do	253	8.16	Do.	Do	253		Do.
Do	253	8.26	Do.	Do	253		Do.
Do	253	8.07	Do.	Do	253		Do.
Do	253	8.07	Do.	Do	253		Do.
Do	253	8.16	Do.	Do	253		Do.
Do	253	8.07	Do.	Do	253		Do.
Do	253	8.07	Do.				
Do	253	8.16	Do.	TEST 4.			
Feb. 12	253	8.07	Do.				
				Feb. 18	[a] 680	3.97	No ignition.
TEST 3.				Do	[a] 680	3.97	Do.
				Do	[a] 680	3.92	Do.
Feb. 16	253		No ignition.	Do	[a] 680	3.87	Do.
Do	253		Do.	Apr. 16	[a] 680	4.04	Do.
Do	253		Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Mar. 4	10.34	43.0	4,159
Mar. 7	9.96	43.0	4,317
Do	9.96	43.0	4,317

Average rate of detonation, 4,264 meters (13,990 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Jan. 28	6.75	8.53	1.75	0.088
Do	3.00	3.79	1.00	.050
Feb. 21	7.00	8.84	1.75	.088

Average height of flame, 7.05 inches.
Average duration of flame, 0.075 millisecond.

IMPACT TEST.

Date, December 5, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
8	1	No explosion.	42	1	No explosion.
16	1	Do.	43	1	Do.
32	1	Do.	43	1	Explosion.
64	1	Explosion.	42	1	Do.
48	1	Do.	41	1	Do.
44	1	Do.	40	5	No explosion.

The maximum height at which no explosion occurs established at 40 centimeters (15.75 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 166 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Dec. 13	4	Did not explode.	Dec. 13	2	Did not explode.
Do	2	Do.	Do	2	Do.
Do	1	Exploded.			

The minimum distance at which no explosion occurs established at 2 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.24 millimeter=1 kilogram per square centimeter.

Date (1912–13).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Jan. 22	217	1.03	22.00	91.67	A	89.24
Do	217	1.03	21.25	88.54	A	
Do	217	1.03	21.00	87.50	A	
Dec. 6	217	1.03	20.00	83.33	B	83.33
Feb. 13	217	1.03	20.25	84.38	B	
Do	217	1.03	19.75	82.29	B	
Jan. 22	217	1.03	19.00	79.17	C	80.56
Do	217	1.03	19.75	82.29	C	
Do	217	1.03	19.25	80.21	C	

[a] Including 17 grams of the original wrapper.

$P = 1.911A + 0.5B - 1.411C = 98.53$ kilograms per square centimeter.

$V = 15{,}000$ cubic centimeters. $S = 1.03$. $W = 217$ grams.

$M = \frac{VPS}{W} = 7{,}015$ kilograms per square centimeter (99,780 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 17 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, July 14, 1910.

	Grams.
Solid	24.5
Liquid (water)	64.5
Gaseous	124.4

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 108.5 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*°C.*	*Calories.*
Jan. 23	81.95	1.060	905.5
Do	81.95	1.094	934.8
Jan. 24	81.95	1.093	934.0

[a] Including 8.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 924.8.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1913).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Jan. 25	64.00	48.00	16.00
Do	63.75	47.25	16.50
Do	64.00	47.50	16.50

Average compression, 16.3 millimeters (0.64 inch).

EXPANSION OF BORE HOLE OF TRAUZL BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Nov. 15	63	310	247	15
Do	63	305	242	15
Nov. 16	63	316	253	15

Average expansion of bore hole, 247 cubic centimeters (15.07 cubic inches).

KANITE A.

Explosive, Kanite A.
Class 1*b*, ammonium nitrate.
Manufactured by the W. H. Blumenstein Chemical Works.
Physical examination:

Diameter of cartridge, 1¼ inches.
Length of cartridge, 8 inches.
Average weight, 289 grams.
Cartridge had not been redipped.
Apparent specific gravity of cartridge by sand, 0.91.
Color of explosive, corn.
Consistency, powdered, very fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, April 5, 1910.
Unit swing on this date, 3.44 inches.
Weight of charge, in grams, 260, 260, 260.
Swing, in inches, 3.54, 3.49, 3.50.
Average swing, in inches, 3.51.

$$3.51 : 3.44 :: 260 : (255).$$

Therefore the unit deflective charge of Kanite A is 255 grams.

GAS AND DUST GALLERY No. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Apr. 6	255	7.99	No ignition.
Do	255	7.80	Do.
Do	255	7.90	Do.
Do	255	7.90	Do.
Do	255	7.90	Do.
Do	255	7.90	Do.
Do	255	7.80	Do.
Do	255	7.90	Do.
Do	255	7.80	Do.
Apr. 7	255	7.80	Do.
TEST 3.			
Apr. 8	255		No ignition.
Do	255		Do.
Do	255		Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Apr. 8	255		No ignition.
Do	255		Do.
Do	255		Do.
Do	255		Do.
Do	255		Do.
Do	255		Do.
Do	255		Do.
TEST 4.			
Apr. 7	[a] 680	3.85	No ignition.
Do	[a] 680	3.80	Do.
Do	[a] 680	3.80	Do.
Do	[a] 680	3.81	Do.
Do	[a] 680	3.85	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¾ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Apr. 6	13.06	43.0	3,292
Do	13.40	43.0	3,209
Do	12.99	43.0	3,310

Average rate of detonation, 3,270 meters (10,730 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Oct. 17	13.50	17.05	6.00	0.300
Do	14.00	17.68	5.50	.275
Do	16.25	20.52	7.75	.388

Average height of flame, 18.42 inches.
Average duration of flame, 0.321 millisecond.

IMPACT TEST.

Date, October 18, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
80	1	Explosion.	51	1	No explosion.
60	1	Do.	51	1	Explosion.
40	1	No explosion.	50	1	Do.
50	1	Do.	46	1	No explosion.
56	1	Explosion.	48	1	Explosion.
54	1	Do.	47	3	No explosion.
52	1	No explosion.	47	1	Explosion.
53	1	Explosion.	46	4	No explosion.
52	1	Do.			

The maximum height at which no explosion occurs established at 46 centimeters (18.11 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 143 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Oct. 31	2	Did not explode.	Oct. 31	1	Did not explode.
Do	1	Do.	Nov. 4	0	Exploded.
Do	1	Do.			

The minimum distance at which no explosion occurs is established at 1 inch.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.24 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Apr. 16	213	0.82	27.50	114.58	A	115.28
Do	213	.82	27.75	115.63	A	
Do	213	.82	27.75	115.63	A	
Apr. 15	213	.82	26.50	110.42	B	112.50
Do	213	.82	27.00	112.50	B	
Apr. 16	213	.82	27.50	114.58	B	
Do	213	.82	24.75	103.13	C	105.56
Do	213	.82	25.75	107.29	C	
Do	213	.82	25.50	106.25	C	

[a] Including 13 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=127.60$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=0.82$. $W=213$ grams.

$M=\frac{VPS}{W}=7{,}368$ kilograms per square centimeter (104,800 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 17 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, September 8, 1910.

	Grams
Solid	12.5
Liquid (water)	86.0
Gaseous	110.6

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.5 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Apr. 17	81.95	1.138	988.4
Do	81.95	1.132	983.1
Do	81.95	1.155	1,003.3

[a] Including 6.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 991.6.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Oct. 23	63.25	49.00	14.25
Do	63.25	49.50	13.75
Do	62.50	48.75	13.75

Average compression, 13.9 millimeters (0.55 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Nov. 11	63	276	213	15
Do	63	270	207	15
Do	63	260	197	15

Average expansion of bore hole, 206 cubic centimeters (12.57 cubic inches).

LOMITE NO. 1.

Explosive, Lomite No. 1.
Class 2, hydrated.
Manufactured by the G. R. McAbee Powder & Oil Co.
Physical examination:
- Diameter of cartridge, 1¼ inches.
- Length of cartridge, 8 inches.
- Average weight, 202 grams.
- Cartridge had been redipped.
- Apparent specific gravity of cartridge by sand, 1.23.
- Color of explosive, corn.
- Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by ballistic pendulum:
Date, October 28, 1912.
Unit swing on this date, 3.43 inches.
Weight of charge, in grams, 295, 295, 295.
Swing, in inches, 3.40, 3.37, 3.33.
Average swing, in inches, 3.37.

3.37 : 3.43 : : 295 : (300).

Therefore the unit deflective charge of Lomite No. 1 is 300 grams.

GAS AND DUST GALLERY NO. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Oct. 31	300	8.18	No ignition.	Nov. 5	300	....	No ignition.
Do	300	7.91	Do.	Do	300	....	Do.
Do	300	7.86	Do.	Do	300	....	Do.
Do	300	8.40	Do.	Do	300	....	Do.
Do	300	8.53	Do.	Do	300	....	Do.
Do	300	7.96	Do.	Do	300	....	Do.
Do	300	8.23	Do.	Do	300	....	Do.
Do	300	8.45	Do.				
Do	300	8.26	Do.	TEST 4.			
Do	300	8.53	Do.				
				Nov. 4	[a] 680	4.18	No ignition.
TEST 3.				Do	[a] 680	4.11	Do.
				Do	[a] 680	4.12	Do.
Nov. 5	300	....	No ignition.	Do	[a] 680	4.18	Do.
Do	300	....	Do.	Do	[a] 680	4.11	Do.
Do	300	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Oct. 31	9.90	42.0	4,242
Nov. 1	9.75	42.0	4,308
Nov. 2	10.00	42.0	4,200

Average rate of detonation, 4,250 meters (13,940 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Feb. 20	10.25	12.95	6.75	0.338
Do	8.75	11.05	5.25	.262
Do	9.00	11.37	6.75	.338

Average height of flame, 11.79 inches.
Average duration of flame, 0.313 millisecond.

IMPACT TEST.

Date, November 8, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
10	1	No explosion.	14	1	No explosion.
20	1	Explosion.	15	5	Do.
16	1	Do.			

The maximum height at which no explosion occurs established at 15 centimeters (5.91 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 198 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Nov. 11	10	Did not explode.	Nov. 11	9	Did not explode.
Do	6	Exploded.	Do	9	Do.
Do	8	Do.	Do	9	Do.

The minimum distance at which no explosion occurs established at 9 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.24 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Dec. 2	212	1.23	15.75	65.63	A	65.28
Do	212	1.23	15.50	64.58	A	
Do	212	1.23	15.75	65.63	A	
Do	212	1.23	14.25	59.38	B	60.07
Do	212	1.23	14.50	60.42	B	
Do	212	1.23	14.50	60.42	B	
Do	212	1.23	14.75	61.46	C	61.46
Do	212	1.23	14.75	61.46	C	
Do	212	1.23	14.75	61.46	C	

[a] Including 12 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=68.07$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.23$. $W=212$ grams.

$M=\frac{VPS}{W}=5{,}924$ kilograms per square centimeter (84,260 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 12 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, November 6, 1912.	Grams.
Solid	69.1
Liquid (water)	18.7
Gaseous	114.6

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.0 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Jan 22	81.95	0.820	715.2
Do	81.95	.784	683.4
Do	81.95	.781	680.8

[a] Including 6 grams of the original wrapper.

Average large calories per kilogram of explosive, 693.1.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1913).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Feb. 25	63.50	47.00	16.50
Do	63.50	47.25	16.25
Do	63.50	47.50	16.00

Average compression, 16.2 millimeters (0.64 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Nov. 14	62	228	166	15
Do	62	221	159	15
Do	62	225	163	15

Average expansion of bore hole, 163 cubic centimeters (9.94 cubic inches).

MINE-ITE A.

Explosive, Mine-ite A.
Class 4, nitroglycerin.
Manufactured by the Burton Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 203 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.14.
  Color of explosive, straw.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:
Date, August 6, 1909.
Unit swing on this date, 2.79 inches.
Weight of charge, 315, 315, 315.
Swing, in inches, 2.95, 2.98, 2.97.
Average swing, in inches, 2.97.

$$2.97 : 2.79 : : 315 : (296).$$

Therefore the unit deflective charge of Mine-ite A is 296 grams.

GAS AND DUST GALLERY NO. 1.

Date (1909).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	Per cent.	
Aug. 7	296	8.30	No ignition.
Do	296	8.30	Do.
Do	296	8.47	Do.
Do	296	8.30	Do.
Do	296	8.47	Do.
Do	296	8.47	Do.
Aug. 9	296	8.23	Do.
Do	296	8.39	Do.
Do	296	8.23	Do.
Aug. 10	296	8.17	Do.
TEST 3.			
Aug. 9	296		No ignition.
Do	296		Do.
Do	296		Do.
TEST 3—Con.			
	Grams.	Per cent.	
Aug. 9	296		No ignition.
Do	296		Do.
Do	296		Do.
Do	296		Do.
Do	296		Do.
Do	296		Do.
Do	296		Do.
TEST 4.			
Aug. 6	[a] 680	4.23	No ignition.
Do	[a] 680	4.40	Do.
Do	[a] 680	4.40	Do.
Do	[a] 680	4.40	Do.
Do	[a] 680	4.02	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	Meters.	Meters.
June 3	12.57	43.0	3,421
Do	12.36	43.0	3,479
Do	12.54	43.0	3,429

Average rate of detonation, 3,443 meters (11,290 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	Inches.	Millimeters.	Milliseconds.
Mar. 24	14.50	18.32	6.25	0.312
Do	13.25	16.74	6.25	.312
Do	16.00	20.21	7.50	.375

Average height of flame, 18.42 inches.
Average duration of flame, 0.333 millisecond.

IMPACT TEST.

Date, May 3, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	12	1	Explosion.
12	1	No explosion.	10	1	Do.
16	1	Explosion.	9	2	No explosion.
13	1	No explosion.	9	1	Explosion.
14	1	Explosion.	8	5	No explosion.
13	1	Do.			

The maximum height at which no explosion occurs established at 8 centimeters (3.15 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 182 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Dec. 5	10	Exploded.	Dec. 6	16	Did not explode.
Do	13	Did not explode.	Do	16	Exploded.
Do	12	Exploded.	Do	17	Do.
Do	14	Did not explode.	Do	18	Do.
Do	13	Do.	Do	19	Did not explode.
Do	13	Exploded.	Do	19	Exploded.
Dec. 6	14	Do.	Dec. 7	20	Did not explode.
Do	15	Did not explode.	Do	20	Do.
Do	15	Do.	Do	20	Do.
Do	15	Exploded.			

The minimum distance at which no explosion occurs established at 20 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Jan. 23	[b] 213	1.13	14.75	61.46	A	62.41
Do	213	1.13	20.00	62.50	A	
Do	213	1.13	20.25	63.28	A	
Do	213	1.13	19.75	61.72	B	62.50
Do	213	1.13	20.00	62.50	B	
Do	213	1.13	20.25	63.28	B	
Do	213	1.13	19.75	61.72	C	61.20
Do	213	1.13	19.75	61.72	C	
Jan. 24	213	1.13	19.25	60.16	C	

[a] Including 13 grams of the original wrapper.
[b] Indicator spring, 0.24 millimeter=1 kilogram per square centimeter.

$P=1.911A+0.5B-1.411C=64.16$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=1.13.$ $W=213$ grams.

$M=\frac{VPS}{W}=5,106$ kilograms per square centimeter (72,620 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 13 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, February 27, 1913.	Grams.
Solid	66. 1
Liquid (water)	20. 0
Gaseous	107. 9

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.5 grams. [a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	° *C.*	*Calories.*
Jan. 4	81. 95	0. 822	713. 6
Jan. 6	81. 95	. 792	687. 2
Do	81. 95	. 811	703. 9

[a] Including 6.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 701.6.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 17	63. 50	50. 00	13. 50
Do	63. 50	50. 00	13. 50
Do	63. 50	50. 00	13. 50

Average compression, 13.5 millimeters (0.53 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	° *C.*
Mar. 19	62	254	192	15
Do	62	253	191	15
Do	62	262	200	15

Average expansion of bore hole, 194 cubic centimeters (11.83 cubic inches).

MINE-ITE A–2.

Explosive, Mine-ite A–2.

Class 4, nitroglycerin.

Manufactured by the Burton Powder Co.

Physical examination:

Diameter of cartridge, 1¼ inches.

Length of cartridge, 8 inches.

Average weight, 151 grams.

Cartridge had not been redipped.

Apparent specific gravity of cartridge by sand, 0.93.

Color of explosive, corn.

Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by ballistic pendulum:

Date, March 11, 1912.

Unit swing on this date, 3.50 inches.

Weight of charge, in grams, 310, 310, 310.

Swing, in inches, 3.32, 3.46, 3.42.

Average swing, in inches, 3.40.

$$3.40 : 3.50 :: 310 : (319).$$

Therefore the unit deflective charge of Mine-ite A–2 is 319 grams.

Gas and Dust Gallery No. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Mar. 12	319	7.99	No ignition.
Do	319	8.23	Do.
Do	319	8.09	Do.
Mar. 13	319	7.76	Do.
Do	319	7.87	Do.
Do	319	7.98	Do.
Do	319	7.91	Do.
Do	319	7.90	Do.
Do	319	7.88	Do.
Do	319	7.85	Do.
TEST 3.			
Mar. 14	319	....	No ignition.
Do	319	....	Do.
Mar. 15	319	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Mar. 15	319	....	No ignition.
Do	319	....	Do.
Do	319	....	Do.
Do	319	....	Do.
Do	319	....	Do.
Do	319	....	Do.
Do	319	....	Do.
TEST 4.			
Mar. 14	[a] 680	4.05	No ignition.
Do	[a] 680	4.03	Do.
Do	[a] 680	4.21	Do.
Do	[a] 680	4.14	Do.
Do	[a] 680	4.08	Do.

[a] 680 grams or more was used.

Rate of Detonation.

Diameter of cartridge, 1¼ inches.

Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Mar. 11	13.85	45.0	3,249
Mar. 15	13.70	44.5	3,248
Do	13.65	44.5	3,260

Average rate of detonation, 3,252 meters (10,670 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
May 14	11.75	14.84	4.00	0.200
Do	9.25	11.68	3.00	.150
Do	12.00	15.16	4.00	.200

Average height of flame, 13.89 inches.

Average duration of flame, 0.183 millisecond.

IMPACT TEST.

Date, April 20, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	18	1	Explosion.
18	1	No explosion.	17	1	Do.
19	3	Do.	16	5	No explosion.
19	1	Explosion.			

The maximum height at which no explosion occurs established at 16 centimeters (6.30 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 150 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
May 3	2	Exploded.	May 3	10	Did not explode.
Do	4	Do.	Do	9	Do.
Do	6	Do.	Do	9	Do.
Do	8	Do.	Do	9	Do.

The minimum distance at which no explosion occurs established at 9 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
May 9	216	0.93	20.00	62.50	A	61.72
Do	216	.93	19.25	60.16	A	
Do	216	.93	20.00	62.50	A	
May 8	216	.93	20.25	63.28	B	61.72
Do	216	.93	19.50	60.94	B	
Do	216	.93	19.50	60.94	B	
Do	216	.93	19.00	59.38	C	58.60
May 9	216	.93	18.25	57.03	C	
Do	216	.93	19.00	59.38	C	

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[a] Including 16 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=66.12$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=0.93$. $W=216$ grams.

$M=\frac{VPS}{W}=4,270$ kilograms per square centimeter (60,730 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 16 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, March 8, 1912.	Grams.
Solid	58.5
Liquid (water)	15.5
Gaseous	129.4

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.5 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
May 12	81.95	0.790	679.2
Do	81.95	.792	680.8
Do	81.95	.826	710.4

[a] Including 7.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 690.1.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Apr. 18	63.25	50.50	12.75
Do	63.25	50.75	12.50
Do	63.25	50.50	12.75

Average compression, 12.7 millimeters (0.50 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Apr. 30	62	211	149	16
Do	62	218	156	16
Do	62	212	150	16

Average expansion of bore hole, 152 cubic centimeters (9.27 cubic inches).

MINE-ITE B.

Explosive, Mine-ite B.
Class 4, nitroglycerin.
Manufactured by the Burton Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 183 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.03.
  Color of explosive, straw.
  Consistency, granular and fibrous,, fine, dry, soft, slightly cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, August 4, 1909.
  Unit swing on this date, 2.95 inches.
  Weight of charge, in grams, 340, 340, 340.
  Swing, in inches, 2.95, 2.92, 2.97.
  Average swing, in inches, 2.95.

$$2.95 : 2.95 :: 340 : (340).$$

Therefore the unit deflective charge of Mine-ite B is 340 grams.

GAS AND DUST GALLERY NO. 1.

Date (1909).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Aug. 4	340	7.88	No ignition.
Do	340	8.63	Do.
Do	340	8.13	Do.
Do	340	8.13	Do.
Do	340	8.37	Do.
Do	340	8.37	Do.
Aug. 5	340	8.30	Do.
Do	340	8.47	Do.
Do	340	8.50	Do.
Do	340	8.47	Do.
TEST 3.			
Aug. 5	340		No ignition.
Do	340		Do.
Do	340		Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Aug. 5	340		No ignition.
Do	340		Do.
Do	340		Do.
Do	340		Do.
Do	340		Do.
Do	340		Do.
Do	340		Do.
TEST 4.			
Aug. 2	[a]680	4.14	No ignition.
Do	[a]680	3.98	Do.
Do	[a]680	3.81	Do.
Do	[a]680	3.90	Do.
Do	[a]680	3.81	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1909–10).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Aug. 25	14.75	43.0	2,915
June 3	15.00	43.0	2,867
Do	14.63	43.0	2,941

Average rate of detonation, 2,908 meters (9,540 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 24	13.00	16.42	5.50	0.275
Do	12.25	15.47	6.25	.312
Do	9.50	12.00	5.00	.250

Average height of flame, 14.63 inches.

Average duration of flame, 0.279 millisecond.

IMPACT TEST.

Date, May 5, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
16	1	Explosion.	9	1	Explosion.
10	1	Do.	8	2	No explosion.
6	1	No explosion.	8	1	Explosion.
8	1	Do.	7	5	No explosion.

The maximum height at which no explosion occurs established at 7 centimeters (2.76 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 159 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Dec. 12	6	Did not explode.	Dec. 12	5	Exploded.
Do.	4	Exploded.	Do.	6	Did not explode.
Do.	5	Did not explode.	Do.	6	Do.

The minimum distance at which no explosion occurs established at 6 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Jan. 25	214	0.99	18.75	58.59	A	58.33
Do	214	.99	18.75	58.59	A	
Do	214	.99	18.50	57.81	A	
Jan. 24	214	.99	17.25	53.91	B	54.17
Jan. 25	214	.99	17.50	54.69	B	
Do	214	.99	17.25	53.91	B	
Jan. 24	214	.99	17.25	53.91	C	53.65
Do	214	.99	17.25	53.91	C	
Do	214	.99	17.00	53.12	C	

[a] Including 14 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=62.85$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=0.99$. $W=214$ grams.

$M=\frac{VPS}{W}=4,361$ kilograms per square centimeter (62,030 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 14 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, December 11, 1912.

	Grams.
Solid	77.7
Liquid (water)	15.5
Gaseous	103.3

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.0 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	° *C.*	*Calories.*
Jan. 17	81.95	0.773	667.5
Do	81.95	.806	696.3
Do	81.95	.789	681.4

[a] Including 7 grams of the original wrapper.

Average large calories per kilogram of explosive, 681.7.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 12	63.75	53.25	10.50
Do	63.75	53.25	10.50
Do	63.75	53.25	10.50

Average compression, 10.5 millimeters (0.41 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	° *C.*
Mar. 19	62	220	158	15
Do	62	222	160	15
Do	62	221	159	15

Average expansion of bore hole, 159 cubic centimeters (9.70 cubic inches).

MINE-ITE B-2.

Explosive, Mine-ite B-2.
Class 4, nitroglycerin.
Manufactured by the Burton Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 127 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 0.77.
  Color of explosive, corn.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.
Unit deflective charge as determined by ballistic pendulum:
  Date, March 11, 1912.
  Unit swing on this date, 3.50 inches.
  Weight of charge, in grams, 325, 325, 325.
  Swing, in inches, 3.38, 3.42, 3.43.
  Average swing, in inches, 3.41.

3.41 : 3.50 : : 325 : (334).

Therefore the unit deflective charge of Mine-ite B-2 is 334 grams.

Gas and Dust Gallery No. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Mar. 12	334	8.04	No ignition.
Do	334	7.96	Do.
Do	334	8.16	Do.
Do	334	8.09	Do.
Do	334	7.94	Do.
Do	334	7.83	Do.
Do	334	7.91	Do.
Do	334	8.06	Do.
Do	334	8.24	Do.
Do	334	8.08	Do.
TEST 3.			
Mar. 14	334	....	No ignition.
Do	334	....	Do.
Do	334	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Mar. 14	334	....	No ignition.
Do	334	....	Do.
Do	334	....	Do.
Do	334	....	Do.
Do	334	....	Do.
Do	334	....	Do.
Do	334	....	Do.
TEST 4.			
Mar. 13	[a] 680	3.97	No ignition.
Do	[a] 680	3.95	Do.
Do	[a] 680	4.18	Do.
Do	[a] 680	4.12	Do.
Mar. 14	[a] 680	3.79	Do.

[a] 680 grams or more was used.

Rate of Detonation.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Mar. 11	20.00	44.5	2,225
Mar. 16	20.00	45.0	2,250
Do	19.30	44.5	2,306

Average rate of detonation, 2,260 meters (7,410 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
May 13	8.00	10.11	3.00	0.150
Do	9.00	11.37	3.50	.175
Do	8.75	11.05	3.50	.175

Average height of flame, 10.84 inches.
Average duration of flame, 0.167 millisecond.

IMPACT TEST.

Date, April 19, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
40	1	Explosion.	25	1	Explosion.
35	1	Do.	23	1	Do.
30	1	Do.	21	1	Do.
25	1	No explosion.	19	1	No explosion.
28	1	Explosion.	20	5	Do.
26	1	Do.			

The maximum height at which no explosion occurs established at 20 centimeters (7.87 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 124 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
May 2	3	Did not explode.	May 2	2	Did not explode.
Do	1	Do.	May 3	2	Do.
Do	0	Exploded.	Do	2	Do.
Do	1	Do.			

The minimum distance at which no explosion occurs established at 2 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter =1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
May 9	217	0.77	17.25	53.91	A	53.13
Do	217	.77	16.50	51.56	A	
Do	217	.77	17.25	53.91	A	
May 7	217	.77	17.00	53.12	B	52.60
May 8	217	.77	16.50	51.56	B	
Do	217	.77	17.00	53.12	B	
May 7	217	.77	16.00	50.00	C	51.56
Do	217	.77	16.75	52.34	C	
Do	217	.77	16.75	52.34	C	

[a] Including 17 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=55.08$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=0.77$. $W=217$ grams.

$M=\frac{VPS}{W}=2{,}932$ kilograms per square centimeter (41,700 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 17 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, March 7, 1912.	Grams.
Solid	67.4
Liquid (water)	12.6
Gaseous	126.2

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Apr. 18	63.25	55.75	7.50
Do	63.25	55.75	7.50
Do	63.25	55.75	7.50

Average compression, 7.5 millimeters (0.30 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Apr. 29	62	218	156	16
Apr. 30	62	220	158	16
Do	62	214	152	16

Average expansion of bore hole, 155 cubic centimeters (9.46 cubic inches).

MINE-ITE NO. 5-D.

Explosive, Mine-ite No. 5-D.

Class, 1*a*, ammonium nitrate, containing nitroglycerin.

Manufactured by the Burton Powder Co.

Physical examination:

Diameter of cartridge, 1¼ inches.

Length of cartridge, 8 inches.

Average weight, 150 grams.

Cartridge had not been redipped.

Apparent specific gravity of cartridge by sand, 0.90.

Color of explosive, corn.

Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, August 29, 1912.
Unit swing on this date, 3.44 inches.
Weight of charge, in grams, 240, 240, 240.
Swing, in inches, 3.49, 3.33, 3.48.
Average swing, in inches, 3.43.

$$3.43 : 3.44 :: 240 : (241).$$

Therefore the unit deflective charge of Mine-ite No. 5–D is 241 grams.

GAS AND DUST GALLERY No. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Aug. 29	241	7.87	No ignition.	Sept. 3	241	....	No ignition.
Do	241	8.25	Do.	Do	241	....	Do.
Do	241	7.85	Do.	Do	241	....	Do.
Do	241	7.93	Do.	Do	241	....	Do.
Aug. 30	241	8.02	Do.	Do	241	....	Do.
Do	241	7.93	Do.	Do	241	....	Do.
Do	241	8.01	Do.	Do	241	....	Do.
Do	241	7.80	Do.				
Do	241	8.24	Do.	TEST 4.			
Do	241	8.30	Do.				
				Aug. 31	[a] 680	4.21	No ignition.
TEST 3.				Do	[a] 680	4.04	Do.
				Do	[a] 680	4.01	Do.
Sept. 3	241	....	No ignition.	Do	[a] 680	4.14	Do.
Do	241	....	Do.	Do	[a] 680	4.22	Do.
Do	241	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Aug. 30	16.45	43.0	2,614
Do	15.80	43.0	2,722
Do	16.30	43.0	2,638

Average rate of detonation, 2,658 meters (8,720 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Sept. 9	8.00	10.11	3.75	0.188
Sept. 10	4.25	5.37	1.50	.075
Do	6.25	7.89	1.50	.075

Average height of flame, 7.79 inches.
Average duration of flame, 0.113 millisecond.

Impact Test.

Date, September 27, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
40	1	Explosion.	13	1	Explosion.
20	1	Do.	11	1	Do.
15	1	Do.	10	5	No explosion.

The maximum height at which no explosion occurs established at 10 centimeters (3.94 inches).

Explosion-by-Influence Test.

Weight of each cartridge, 145 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Sept. 3	3	Did not explode.	Sept. 3	2	Exploded.
Do	2	Do.	Do	3	Did not explode.
Do	1	Exploded.	Do	3	Do.

The minimum distance at which no explosion occurs established at 3 inches.

Theoretical Maximum Pressure Developed in Own Volume, as Determined by Bichel Pressure Gage.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Oct. 18	218	0.90	30.00	93.75	A	92.19
Oct. 21	218	.90	29.50	92.19	A	
Do	218	.90	29.00	90.62	A	
Oct. 18	218	.90	28.00	87.50	B	88.28
Do	218	.90	28.50	89.06	B	
Do	218	.90	28.25	88.28	B	
Oct. 7	218	.90	26.75	83.59	C	83.59
Oct. 9	218	.90	27.25	85.16	C	
Do	218	.90	26.25	82.03	C	

[a] Including 18 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=102.37$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=0.90$. $W=218$ grams.

$M=\frac{VPS}{W}=6.339$ kilograms per square centimeter (90,160 pounds per square inch).

Products of Combustion from 200 Grams of the Explosive and 18 Grams of the Original Wrapper.

[Analyst, A. L. Hyde.]

Date, September 4, 1912.

	Grams.
Solid	20.5
Liquid (water)	68.0
Gaseous	119.4

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 109.0 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Sept. 14	81.95	1.155	982.8
Sept. 16	81.95	1.169	994.9
Do	81.95	1.115	948.5

[a] Including 9 grams of the original wrapper.

Average large calories per kilogram of explosive, 975.4.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Sept. 23	63.25	50.75	12.50
Do	63.25	51.25	12.00
Sept. 24	63.25	51.25	12.00

Average compression, 12.2 millimeters (0.48 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Oct. 17	62	291	229	15
Do	62	291	229	15
Do	62	294	232	15

Average expansion of bore hole, 230 cubic centimeters (14.03 cubic inches).

MONOBEL NO. 2.

Explosive, Monobel No. 2.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the E. I. du Pont de Nemours Powder Co.
Physical examination:
    Diameter of cartridge, 1½ inches.
    Length of cartridge, 8 inches.
    Average weight, 236 grams.
    Cartridge had been redipped.
    Apparent specific gravity of cartridge by sand, 0.98.
    Color of explosive, straw.
    Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, February 7, 1910.
Unit swing on this date, 2.99 inches.
Weight of charge, in grams, 240, 240, 240.
Swing, in inches, 2.95, 3.04, 3.02.
Average swing, in inches, 3.00.

3.00 : 2.99 : : 240 : (239).

Therefore the unit deflective charge of Monobel No. 2 is 239 grams.

GAS AND DUST GALLERY No. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Feb. 10	239	8.26	No ignition.
Do	239	7.97	Do.
Do	239	7.92	Do.
Do	239	7.97	Do.
Do	239	8.16	Do.
Do	239	7.97	Do.
Do	239	7.87	Do.
Do	239	8.06	Do.
Feb. 11	239	7.87	Do.
Do	239	8.16	Do.
TEST 3.			
Feb. 15	239	....	No ignition.
Do	239	....	Do.
Do	239	....	Do.
TEST 3—Con.			
Feb. 15	239	....	No ignition.
Do	239	....	Do.
Do	239	....	Do.
Do	239	....	Do.
Feb. 16	239	....	Do.
Do	239	....	Do.
Do	239	....	Do.
TEST 4.			
Feb. 18	[a] 680	3.83	No ignition.
Do	[a] 680	4.02	Do.
Do	[a] 680	3.92	Do.
Do	[a] 680	4.02	Do.
Do	[a] 680	3.87	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Feb. 7	14.34	43.0	2,999
Feb. 8	14.30	43.0	3,007
Do	14.23	43.0	3,022

Average rate of detonation, 3,009 meters (9,870 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Jan. 29	6.00	7.58	1.50	0.075
Do	7.75	9.79	2.00	.100
Do	8.50	10.74	2.00	.100

Average height of flame, 9.37 inches.
Average duration of flame, 0.092 millisecond.

IMPACT TEST.

Date, March 2, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
30	1	Explosion.	21	1	Explosion.
24	1	No explosion.	20	1	No explosion.
25	1	Explosion.	20	1	Explosion.
24	1	Do.	19	1	Do.
23	1	No explosion.	18	1	Do.
23	1	Explosion.	17	1	No explosion.
22	1	No explosion.	17	1	Explosion.
22	1	Explosion.	16	5	No explosion.

The maximum height at which no explosion occurs established at 16 centimeters (6.30 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 162 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Dec. 13	6	Exploded.	Dec. 13	10	Exploded.
Do	10	Did not explode.	Do	11	Did not explode.
Do	8	Exploded.	Do	11	Do.
Do	9	Do.	Do	11	Do.

The minimum distance at which no explosion occurs established at 11 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1910).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Oct. 29	[b] 218	0.98	37.50	93.75	A	92.97
Do	218	.98	29.50	92.19	A	
Oct. 31	218	.98	29.75	92.97	A	
Nov. 25	218	.98	28.50	89.06	B	88.54
Do	218	.98	28.50	89.06	B	
Nov. 28	218	.98	28.00	87.50	B	
Do	218	.98	27.25	85.16	C	84.38
Do	218	.98	26.25	82.03	C	
Do	218	.98	27.50	85.94	C	

[a] Including 18 grams of the original wrapper.

[b] Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

$P=1.911A+0.5B-1.411C=102.88$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=0.98$. $W=218$ grams.

$M=\frac{VPS}{W}=6,937$ kilograms per square centimeter (98,670 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 19 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, July 8, 1910.

	Grams.
Solid	20.4
Liquid (water)	67.5
Gaseous	128.5

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 109.0 grams.[a]

Date (1910).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°C.	*Calories.*
Nov. 16	79.85	0.968	803.9
Nov. 17	79.85	.945	784.5
Nov. 18	79.85	.950	788.7

[a] Including 9 grams of the original wrapper.

Average large calories per kilogram of explosive, 792.4

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 15	63.25	49.00	14.25
Do	63.25	49.50	13.75
Do	63.25	49.00	14.25

Average compression, 14.1 millimeters (0.56 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°C.
Nov. 11	63	316	253	15
Do	63	317	254	15
Do	63	326	263	15

Average expansion of bore hole, 257 cubic centimeters (15.68 cubic inches).

MONOBEL NO. 3.

Explosive, Monobel No. 3.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the E. I. du Pont de Nemours Powder Co.
Physical examination:
  Diameter of cartridge, 1½ inches.
  Length of cartridge, 8 inches.
  Average weight, 221 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 0.93.
  Color of explosive, straw.
  Consistency, granular and fibrous, fine, dry, hard, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, February 14, 1910.
Unit swing on this date, 3.37 inches.
Weight of charge, in grams, 250, 250, 250.
Swing, in inches, 3.50, 3.41, 3.49.
Average swing, in inches, 3.47.

$$3.47 : 3.37 :: 250 : (243).$$

Therefore the unit deflective charge of Monobel No. 3 is 243 grams.

GAS AND DUST GALLERY NO. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Feb. 14	243	8.05	No ignition.
Do	243	8.13	Do.
Feb. 15	243	8.13	Do.
Do	243	8.13	Do.
Do	243	8.05	Do.
Do	243	7.77	Do.
Do	243	8.13	Do.
Do	243	7.95	Do.
Do	243	8.13	Do.
Do	243	8.13	Do.
TEST 3.			
Feb. 17	243	....	No ignition.
Do	243	....	Do.
Do	243	....	Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Feb. 17	243	....	No ignition.
Do	243	....	Do.
Do	243	....	Do.
Do	243	....	Do.
Do	243	....	Do.
Do	243	....	Do.
Do	243	....	Do.
TEST 4.			
Mar. 3	[a] 680	3.87	No ignition.
Mar. 7	[a] 680	3.92	Do.
Do	[a] 680	3.97	Do.
Do	[a] 680	3.87	Do.
Do	[a] 680	3.87	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Mar. 7	19.58	43.0	2,196
Mar. 8	19.37	43.0	2,220
Do	19.36	43.0	2,221

Average rate of detonation, 2,212 meters (7,260 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1913).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Jan. 29	6.75	8.53	1.75	0.088
Do	8.75	11.05	2.50	.125
Do	7.75	9.79	2.25	.112

Average height of flame, 9.79 inches.
Average duration of flame, 0.108 millisecond.

IMPACT TEST.

Date, March 2, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	No explosion.	18	3	No explosion.
20	1	Explosion.	18	1	Explosion.
19	1	No explosion.	17	1	Do.
19	1	Explosion.	16	5	No explosion.

The maximum height at which no explosion occurs is established at 16 centimeters (6.30 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 150 grams.

Date (1910).	Distance separating cartridges.	Result, upper cartridge.	Date (1910).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Nov. 29......	4	Did not explode.	Nov. 30......	5	Did not explode.
Do.......	3	Exploded.	Do.......	5	Do.
Do.......	4	Did not explode.	Do.......	5	Do.
Do.......	4	Exploded.			

The minimum distance at which no explosion occurs established at 5 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

Date (1910).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Oct. 19..............................	220	0.93	37.00	92.50	A	91.25
Oct. 20..............................	220	.93	36.50	91.25	A	
Do..............................	220	.93	36.00	90.00	A	
Oct. 21..............................	220	.93	34.00	85.00	B	85.83
Do..............................	220	.93	34.50	86.25	B	
Do..............................	220	.93	34.50	86.25	B	
Oct. 20..............................	220	.93	32.50	81.25	C	79.79
Do..............................	220	.93	31.50	78.75	C	
Do..............................	220	.93	31.75	79.37	C	

[a] Including 20 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=104.71$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=0.93$. $W=220$ grams.

$M=\frac{VPS}{W}=6{,}640$ kilograms per square centimeter (94,450 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 20 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, July 11, 1910.

	Grams.
Solid..	23.0
Liquid (water)..	67.0
Gaseous..	130.8

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 110.0 grams.[a]

Date (1910).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Nov. 18	80.05	0.919	757.4
Do	80.05	.911	750.8
Nov. 19	80.05	.915	754.1

[a] Including 10 grams of the original wrapper.

Average large calories per kilogram of explosive, 754.1.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 15	63.25	53.25	10.00
Do	63.25	53.25	10.00
Do	63.25	54.00	9.25

Average compression, 9.8 millimeters (0.39 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Nov. 11	63	310	247	15
Do	63	310	247	15
Do	63	319	256	15

Average expansion of bore hole, 250 cubic centimeters (15.25 cubic inches).

MONOBEL NO. 4.

Explosive, Monobel No. 4.

Class 1*a*, ammonium nitrate, containing nitroglycerin.

Manufactured by the E. I. du Pont de Nemours Powder Co.

Physical examination:

- Diameter of cartridge, 7/8 inch.
- Length of cartridge, 8 inches.
- Average weight, 95 grams.
- Cartridge had been redipped.
- Apparent specific gravity of cartridge by sand, 1.08.
- Color of explosive, corn.
- Consistency, fibrous, fine, very dry, very soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, January 23, 1911.
Unit swing on this date, 3.05 inches.
Weight of charge, in grams, 250, 250, 250.
Swing, in inches, 3.05, 3.13, 3.02.
Average swing, in inches, 3.07.

3.07 : 3.05 : : 250 : (248).

Therefore the unit deflective charge of Monobel No. 4 is 248 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.	Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*		TEST 3—Con.	*Grams.*	*Per cent.*	
Jan. 26	248	8.02	No ignition.	Feb. 3	248	....	No ignition.
Do	248	8.20	Do.	Do	248	....	Do.
Do	248	8.10	Do.	Do	248	....	Do.
Do	248	8.03	Do.	Do	248	....	Do.
Do	248	8.04	Do.	Feb. 4	248	....	Do.
Jan. 27	248	7.94	Do.	Do	248	....	Do.
Do	248	7.94	Do.	Do	248	....	Do.
Do	248	7.96	Do.				
Do	248	7.89	Do.	TEST 4.			
Do	248	8.02	Do.				
				Jan. 31	[a] 680	3.98	No ignition.
TEST 3.				Do	[a] 680	3.93	Do.
				Feb. 1	[a] 680	4.07	Do.
Feb. 3	248	....	No ignition.	Do	[a] 680	4.02	Do.
Do	248	....	Do.	Do	[a] 680	4.12	Do.
Do	248	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Jan. 31	16.37	45.0	2,749
Do	16.50	45.0	2,727
Do	16.43	45.0	2,739

Average rate of detonation, 2,738 meters (8,980 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Aug. 14	10.00	12.63	2.50	0.125
Sept. 28	8.75	11.05	3.00	.150
Do	9.50	11.93	2.50	.125

Average height of flame, 11.87 inches.
Average duration of flame, 0.133 millisecond.

Impact Test.

Date, July 26, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	13	1	Explosion.
18	1	Do.	12	5	No explosion.

The maximum height at which no explosion occurs established at 12 centimeters (4.72 inches).

Explosion-by-Influence Test.

Weight of each cartridge, 184 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Sept. 23	3	Exploded.	Sept. 27	4	Did not explode.
Do	5	Did not explode.	Do	4	Do.
Sept. 25	4	Do.			

The minimum distance at which no explosion occurs established at 4 inches.

Theoretical Maximum Pressure Developed in Own Volume, as Determined by Bichel Pressure Gage.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
July 26	[b] 222	1.08	35.00	87.50	A	88.54
Do	222	1.08	28.75	89.85	A	
Do	222	1.08	28.25	88.28	A	
July 27	222	1.08	25.00	78.12	B	79.69
Do	222	1.08	25.50	79.69	B	
Do	222	1.08	26.00	81.25	B	
Do	222	1.08	22.25	69.53	C	71.09
Do	222	1.08	23.25	72.66	C	
Do	222	1.08	22.75	71.09	C	

[a] Including 22 grams of the original wrapper.

[b] Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

$P=1.911A+0.5B-1.411C=108.74$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.08$. $W=222$ grams.

$M=\frac{VPS}{W}=7{,}935$ kilograms per square centimeter (112,870 pounds per square inch).

Products of Combustion from 200 Grams of the Explosive and 22 Grams of the Original Wrapper.

[Analyst, A. L. Hyde.]

Date, June 19, 1911.

	Grams.
Solid	22.7
Liquid (water)	63.5
Gaseous	131.8

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 111.0 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°*C.*	*Calories.*
July 27	80.95	0.978	807.2
Do	80.95	.982	810.6
July 28	80.95	.983	811.4

[a] Including 11 grams of the original wrapper.

Average large calories per kilogram of explosive, 809.7.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Aug. 31	63.50	49.25	14.25
Do	63.25	49.25	14.00
Do	63.50	49.75	13.75

Average compression, 14.0 millimeters (0.55 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Apr. 7	63	302	239	15
Do	63	300	237	15
Do	63	306	243	15

Average expansion of bore hole, 240 cubic centimeters (14.64 cubic inches).

MONOBEL NO. 5.

Explosive, Monobel No. 5.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the E. I. du Pont de Nemours Powder Co.
Physical examination:
  Diameter of cartridge, 1 inch.
  Length of cartridge, 8 inches.
  Average weight, 113 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 1.03.
  Color of explosive, corn.
  Consistency, granular, fine, very dry, very soft, not cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, January 23, 1911.
Unit swing on this date, 3.05 inches.
Weight of charge, in grams, 265, 265, 265.
Swing, in inches, 3.00, 3.08, 3.01.
Average swing, in inches, 3.03.
3.03 : 3.05 : : 265 : (267).

Therefore the unit deflective charge of Monobel No. 5 is 267 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Jan. 27	267	8.09	No ignition.
Do	267	8.14	Do.
Do	267	8.22	Do.
Do	267	8.09	Do.
Do	267	7.85	Do.
Do	267	7.91	Do.
Do	267	7.89	Do.
Do	267	8.05	Do.
Do	267	8.20	Do.
Do	267	8.11	Do.
TEST 3.			
Feb. 4	267	....	No ignition.
Do	267	....	Do.
Do	267	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Feb. 4	267	....	No ignition.
Do	267	....	Do.
Do	267	....	Do.
Do	267	....	Do.
Do	267	....	Do.
Do	267	....	Do.
Do	267	....	Do.
TEST 4.			
Feb. 1	[a] 680	4.11	No ignition.
Do	[a] 680	3.96	Do.
Do	[a] 680	4.01	Do.
Do	[a] 680	4.22	Do.
Do	[a] 680	3.99	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1913).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Jan. 9	21.85	45.0	2,059
Jan. 16	21.75	45.0	2,069
Jan. 17	21.90	45.0	2,055

Average rate of detonation, 2,061 meters (6,760 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1911).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Sept. 28	7.00	8.84	2.50	0.125
Do	10.00	12.63	3.50	.175
Do	8.00	10.10	2.75	.138

Average height of flame, 10.52 inches.
Average duration of flame, 0.146 millisecond.

IMPACT TEST.

Date, July 25, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	10	1	No explosion.
19	1	Do.	11	1	Explosion.
16	1	Do.	10	4	No explosion.
12	1	Do.			

The maximum height at which no explosion occurs established at 10 centimeters (3.94 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 175 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Sept. 28	4	Did not explode.	Sept. 28	3	Did not explode.
Do	3	Do.	Do	3	Do.
Do	2	Exploded.			

The minimum distance at which no explosion occurs established at 3 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
July 29	215	1.03	27.00	84.38	A	86.72
Do	215	1.03	28.25	88.28	A	
Do	215	1.03	28.00	87.50	A	
July 28	215	1.03	26.00	81.25	B	80.47
Do	215	1.03	26.00	81.25	B	
Do	215	1.03	25.25	78.91	B	
July 27	215	1.03	23.00	71.88	C	72.40
Do	215	1.03	22.75	71.09	C	
July 28	215	1.03	23.75	74.22	C	

[a] Including 15 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=103.80$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.03.$ $W=215$ grams.

$M=\frac{VPS}{W}=7{,}459$ kilograms per square centimeter (106,100 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 15 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 20, 1911.	Grams.
Solid	23.7
Liquid (water)	62.5
Gaseous	125.5

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.5 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
July 28	80.95	0.973	829.2
Do	80.95	1.005	856.7
Do	80.95	1.000	852.5

[a] Including 7.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 846.1.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Aug. 31	63.00	51.00	12.00
Do	63.50	51.25	12.25
Do	63.50	51.25	12.25

Average compression, 12.2 millimeters (0.48 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Apr. 6	63	210	147	15
Do	63	209	146	15
Do	63	210	147	15

Average expansion of bore hole, 147 cubic centimeters (8.97 cubic inches).

MONOBEL NO. 6.

Explosive, Monobel No. 6.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the E. I. du Pont de Nemours Powder Co.
Physical examination:

- Diameter of cartridge, ⅞ inch.
- Length of cartridge, 8 inches.
- Average weight, 96 grams.
- Cartridge had been redipped.
- Apparent specific gravity of cartridge by sand, 1.12.
- Color of explosive, corn.
- Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, February 13, 1912.
Unit swing on this date, 3.37 inches.
Weight of charge, in grams, 220, 220, 220.
Swing, in inches, 3.31, 3.45, 3.45.
Average swing, in inches, 3.40.

3.40 : 3.37 : : 220 : (218).

Therefore the unit deflective charge of Monobel No. 6 is 218 grams.

GAS AND DUST GALLERY NO. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Feb. 13	218	8.12	No ignition.
Do	218	7.79	Do.
Do	218	8.27	Do.
Do	218	8.08	Do.
Do	218	8.33	Do.
Do	218	8.10	Do.
Do	218	8.21	Do.
Do	218	8.25	Do.
Do	218	8.12	Do.
Do	218	8.40	Do.
TEST 3.			
Feb. 15	218		No ignition.
Do	218		Do.
Do	218		Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Feb. 16	218		No ignition.
Do	218		Do.
Do	218		Do.
Do	218		Do.
Do	218		Do.
Do	218		Do.
Do	218		Do.
TEST 4.			
Feb. 16	[a] 680	4.04	No ignition.
Do	[a] 680	4.11	Do.
Do	[a] 680	3.92	Do.
Feb. 17	[a] 680	4.07	Do.
Do	[a] 680	3.91	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Feb. 14	14.20	45.0	3,169
Feb. 15	14.10	45.0	3,191
Feb. 16	14.35	45.0	3,136

Average rate of detonation, 3,165 meters (10,380 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
May 15	11.00	13.89	2.25	0.112
Do	9.25	11.68	3.50	.175
Do	16.50	20.84	6.00	.300

Average height of flame, 15.47 inches.
Average duration of flame, 0.196 millisecond.

IMPACT TEST.

Date, April 19, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	No explosion.	23	1	Explosion.
25	1	Explosion.	22	3	No explosion.
23	1	No explosion.	22	1	Explosion.
24	4	Do.	21	5	No explosion.
24	1	Explosion.			

The maximum height at which no explosion occurs established at 21 centimeters (8.27 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 180 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
May 3	7	Did not explode.	May 3	4	Exploded.
Do	3	Exploded.	May 4	5	Did not explode.
Do	5	Did not explode.	Do	5	Do.

The minimum distance at which no explosion occurs established at 5 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Apr. 26	221	1.12	33.00	103.12	A	104.68
Do	221	1.12	34.50	107.81	A	
Do	221	1.12	33.00	103.12	A	
May 3	221	1.12	30.75	96.09	B	94.27
Do	221	1.12	29.50	92.19	B	
Do	221	1.12	30.25	94.53	B	
Do	221	1.12	29.25	91.41	C	92.71
May 4	221	1.12	29.50	92.19	C	
Do	221	1.12	30.25	94.53	C	

[a] Including 21 grams of the original wrapper.

P=1.911A+0.5B−1.411C=116.36 kilograms per square centimeter.

V=15,000 cubic centimeters. S=1.12. W=221 grams.

$M=\frac{VPS}{W}$=8,845 kilograms per square centimeter (125,800 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 21 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, March 5, 1912.	Grams.
Solid	11.2
Liquid (water)	65.0
Gaseous	137.3

Large Calories Developed by 1 Kilogram of the Explosive.

Charge, 110.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*°C.*	*Calories.*
Mar. 12	81.95	1.308	1,099.0
Mar. 13	81.95	1.326	1,114.2
Mar. 22	81.95	1.300	1,092.2

[a] Including 10.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 1,101.8.

Compression of Small Lead Blocks.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Apr. 17	63.50	48.00	15.50
Do	63.25	48.00	15.25
Do	63.50	48.50	15.00

Average compression, 15.2 millimeters (0.60 inch).

Expansion of Bore Hole of Trauzl Lead Blocks.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Apr. 25	62	342	280	19
Do	62	340	278	19
Apr. 26	62	340	278	18

Average expansion of bore hole, 279 cubic centimeters (17.02 cubic inches).

MONOBEL NO. 7.

Explosive, Monobel No. 7.

Class 1*a*, ammonium nitrate, containing nitroglycerin.

Manufactured by the E. I. du Pont de Nemours Powder Co.

Physical examination:

- Diameter of cartridge, $\frac{7}{8}$ inch.
- Length of cartridge, 8 inches.
- Average weight, 93 grams.
- Cartridge had been redipped.
- Apparent specific gravity of cartridge by sand, 1.09.
- Color of explosive, corn.
- Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, February 13, 1912.
Unit swing on this date, 3.37 inches.
Weight of charge, in grams, 220, 220, 220.
Swing, in inches, 3.57, 3.46, 3.53.
Average swing, in inches, 3.52.

3.52 : 3.37 : : 220 : (211).

Therefore the unit deflective charge of Monobel No. 7 is 211 grams.

GAS AND DUST GALLERY No. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Feb. 14	211	8.27	No ignition.
Do	211	8.32	Do.
Do	211	8.30	Do.
Do	211	8.47	Do.
Do	211	8.25	Do.
Do	211	8.27	Do.
Do	211	8.54	Do.
Do	211	8.28	Do.
Feb. 15	211	8.08	Do.
Do	211	8.25	Do.
TEST 3.			
Feb. 15	211		No ignition.
Do	211		Do.
Do	211		Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Feb. 15	211		No ignition.
Do	211		Do.
Do	211		Do.
Do	211		Do.
Do	211		Do.
Do	211		Do.
Do	211		Do.
TEST 4.			
Feb. 17	[a] 680	4.08	No ignition.
Do	[a] 680	4.15	Do.
Do	[a] 680	4.03	Do.
Do	[a] 680	4.08	Do.
Do	[a] 680	4.25	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Feb. 14	14.85	45.0	3,030
Feb. 16	14.60	45.0	3,082
Do	14.60	45.0	3,082

Average rate of detonation, 3,065 meters (10,050 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
May 11	11.75	14.84	6.00	0.300
Do	11.75	14.84	5.50	.275
Do	13.00	16.42	5.50	.275

Average height of flame, 15.37 inches.
Average duration of flame, 0.283 millisecond.

IMPACT TEST.

Date, April 20, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	No explosion.	32	1	Explosion.
25	1	Do.	31	1	No explosion.
35	1	Explosion.	31	1	Explosion.
32	1	No explosion.	30	5	No explosion.
33	1	Explosion.			

The maximum height at which no explosion occurs established at 30 centimeters (11.81 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 175 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
May 4	4	Exploded.	May 4	5	Exploded.
Do	6	Did not explode.	May 6	6	Did not explode.
Do	5	Do.	Do	6	Do.

The minimum distance at which no explosion occurs established at 6 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Apr. 26	220	1.09	33.00	103.12	A	102.86
Do	220	1.09	32.75	102.34	A	
Do	220	1.09	33.00	103.12	A	
May 6	220	1.09	30.50	95.31	B	94.01
Do	220	1.09	30.25	94.53	B	
Do	220	1.09	29.50	92.19	B	
May 7	220	1.09	30.50	95.31	B	95.57
Do	220	1.09	31.00	96.88	B	
Do	220	1.09	30.25	94.53	B	

[a] Including 20 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=108.72$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.09$. $W=220$ grams.

$M=\frac{VPS}{W}=8{,}080$ kilograms per square centimeter (114,920 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 20 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, March 6, 1912.	Grams.
Solid	10.0
Liquid (water)	69.5
Gaseous	134.4

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 110.0 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Mar. 20	81.95	1.238	1,044.5
Feb. 24	81.95	1.234	1,041.1
Do	81.95	1.263	1,065.7

[a] Including 10 grams of the original wrapper.

Average large calories per kilogram of explosive, 1,050.4.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Apr. 17	63.25	47.75	15.50
Do	63.25	47.75	15.50
Do	63.25	48.00	15.25

Average compression, 15.4 millimeters (0.61 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*° C.*
Apr. 25	62	340	278	19
Do	62	334	272	19
Apr. 29	62	344	282	16

Average expansion of bore hole, 277 cubic centimeters (16.90 cubic inches).

NITRO LOW-FLAME NO. 1.

Explosive, Nitro low-flame No. 1.
Class 4, nitroglycerin.
Manufactured by the Nitro Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 218 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.22.
  Color of explosive, straw.
  Consistency, powdered, very fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, September 15, 1910.

Unit swing on this date, 3.32 inches.

Weight of charge, in grams, 300, 300, 300.

Swing, in inches, 3.34, 3.34, 3.20.

Average swing, in inches, 3.29.

3.29 : 3.32 : : 300 : (303).

Therefore the unit deflective charge of Nitro low-flame No. 1 is 303 grams.

GAS AND DUST GALLERY No. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Sept. 19	303	8.22	No ignition.
Do	303	8.16	Do.
Do	303	8.20	Do.
Do	303	8.16	Do.
Do	303	8.30	Do.
Do	303	8.30	Do.
Do	303	8.07	Do.
Do	303	8.24	Do.
Do	303	8.26	Do.
Do	303	7.92	Do.
TEST 3.			
Sept. 20	303		No ignition.
Do	303		Do.
Do	303		Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Sept. 20	303		No ignition.
Do	303		Do.
Do	303		Do.
Do	303		Do.
Do	303		Do.
Do	303		Do.
TEST 4.			
Sept. 16	[a]680	4.18	No ignition.
Do	[a]680	4.22	Do.
Do	[a]680	4.22	Do.
Do	[a]680	4.13	Do.
Do	[a]680	4.18	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.

Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Sept. 16	10.70	43.5	4,065
Do	10.80	43.5	4,028
Do	10.50	43.5	4,143

Average rate of detonation, 4,079 meters (13,380 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Sept. 23	12.50	15.79	5.50	0.275
Do	14.75	18.63	5.50	.275
Sept. 30	11.25	14.21	4.75	.238

Average height of flame, 16.21 inches.

Average duration of flame, 0.263 millisecond.

IMPACT TEST.

Date, February 18, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
26	1	Explosion.	20	1	Explosion.
20	1	No explosion.	16	1	Do.
24	1	Explosion.	14	2	No explosion.
22	1	No explosion.	14	1	Explosion.
23	1	Do.	13	2	No explosion.
23	1	Explosion.	13	1	Explosion.
22	1	Do.	12	5	No explosion.

The maximum height at which no explosion occurs established at 12 centimeters (4.72 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 196 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Feb. 17	8	Did not explode.	Feb. 18	5	Exploded.
Do.	4	Exploded.	Do	6	Did not explode.
Do	6	Did not explode.	Do	6	Do.

The minimum distance at which no explosion occurs established at 6 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Mar. 3	214.8	1.22	25.00	62.50	A	62.08
Mar. 7	214.8	1.22	24.25	60.62	A	
Mar. 13	214.8	1.22	25.25	63.12	A	
Mar. 2	214.8	1.22	25.00	62.50	B	62.29
Do	214.8	1.22	24.75	61.88	B	
Do	214.8	1.22	25.00	62.50	B	
Mar. 3	214.8	1.22	21.50	53.75	C	54.58
Do	214.8	1.22	22.00	55.00	C	
Do	214.8	1.22	22.00	55.00	C	

[a] Including 14.8 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=72.77$ kilograms per square centimeter.

$V=15,000$ cubic centimeters. $S=1.22$. $W=214.8$ grams.

$M=\frac{VPS}{W}=6,200$ kilograms per square centimeter (88,190 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 14.8 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, February 20, 1911.	Grams.
Solid	60.5
Liquid (water)	11.5
Gaseous	134.3

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 107.4 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Feb. 28	80.95	0.698	593.2
Do	80.95	.714	606.9
Do	80.95	.704	598.3

[a] Including 7.4 grams of the original wrapper.

Average large calories per kilogram of explosive, 599.5.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 10	63.50	45.25	18.25
Do	63.50	45.50	18.00
Do	63.50	45.25	18.25

Average compression, 18.2 millimeters (0.72 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Feb. 27	63	215	152	15
Do	63	212	149	15
Do	63	219	156	15

Average expansion of bore hole, 152 cubic centimeters (9.27 cubic inches).

NITRO LOW-FLAME NO. 2.

Explosive, Nitro low-flame No. 2.
Class 4, nitroglycerin.
Manufactured by the Nitro Powder Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 244 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.31.
  Color of explosive, straw.
  Consistency, powdered, very fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, September 15, 1910.
Unit swing on this date, 3.32 inches.
Weight of charge, in grams, 285, 285, 285.
Swing, in inches, 3.10, 3.16, 3.25.
Average swing, in inches, 3.17.

$$3.17 : 3.32 : : 285 : (298).$$

Therefore the unit deflective charge of Nitro low-flame No. 2 is 298 grams.

GAS AND DUST GALLERY NO. 1.

Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Sept. 19	298	8.07	No ignition.
Do	298	8.31	Do.
Do	298	7.94	Do.
Do	298	8.25	Do.
Do	298	7.97	Do.
Do	298	8.07	Do.
Do	298	8.07	Do.
Do	298	8.05	Do.
Do	298	8.07	Do.
Sept. 20	298	8.07	Do.
TEST 3.			
Sept. 20	298	....	No ignition.
Do	298	....	Do.
Sept. 21	298	....	Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Sept. 21	298	....	No ignition.
Do	298	....	Do.
Do	298	....	Do.
Do	298	....	Do.
Do	298	....	Do.
Do	298	....	Do.
Do	298	....	Do.
TEST 4.			
Sept. 17	[a] 680	4.18	No ignition.
Do	[a] 680	4.47	Do.
Do	[a] 680	4.32	Do.
Do	[a] 680	4.27	Do.
Oct. 12	[a] 680	3.94	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Sept. 16	9.57	43.5	4,545
Sept. 19	10.00	43.5	4,350
Do	9.84	43.5	4,421

Average rate of detonation, 4,439 meters (14,560 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Sept. 30	17.75	22.42	7.25	0.362
Do	20.25	25.58	10.50	.525
Do	22.75	28.74	11.00	.550

Average height of flame, 25.58 inches.
Average duration of flame, 0.479 millisecond.

IMPACT TEST.

Date, February 18, 1911.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
16	1	No explosion.	20	1	Explosion.
18	1	Do.	18	1	Do.
20	1	Do.	16	1	Do.
24	1	Explosion.	15	1	Do.
22	1	Do.	14	5	No explosion.

The maximum height at which no explosion occurs established at 14 centimeters (5.51 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 211 grams.

Date (1911).	Distance separating cartridges.	Result, upper cartridge.	Date (1911).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Feb. 18	6	No explosion.	Feb. 18	6	No explosion.
Do	5	Explosion.	Feb. 20	6	Do.

The minimum distance at which no explosion occurs established at 6 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

Date (1911).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Mar. 14	212	1.31	27.00	67.50	A	67.71
Do	212	1.31	27.00	67.50	A	
Do	212	1.31	27.25	68.12	A	
Do	212	1.31	25.50	63.75	B	63.54
Do	212	1.31	25.00	62.50	B	
Do	212	1.31	25.75	64.38	B	
Do	212	1.31	23.50	58.75	C	59.37
Do	212	1.31	24.25	60.62	C	
Do	212	1.31	23.50	58.75	C	

[a] Including 12 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=77.39$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.31$. $W=212$ grams.

$M=\frac{VPS}{W}=7{,}173$ kilograms per square centimeter (102,030 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 12 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, February 21, 1911.	Grams.
Solid	64.3
Liquid (water)	14.3
Gaseous	124.7

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.0 grams.[a]

Date (1911).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°C.	*Calories.*
Mar. 1	80.95	0.746	642.9
Do	80.95	.777	669.9
Do	80.95	.752	648.1

[a] Including 6 grams of the original wrapper.

Average large calories per kilogram of explosive, 653.6.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1911).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 10	63.50	45.25	18.25
Do	63.50	44.75	18.75
Do	63.50	44.50	19.00

Average compression, 18.7 millimeters (0.74 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1911).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°C.
Feb. 27	63	232	169	15
Do	63	226	163	15
Do	63	230	167	15

Average expansion of bore hole, 166 cubic centimeters (10.13 cubic inches).

TROJAN COAL POWDER H.

Explosive, Trojan coal powder H.
Class 3, organic nitrate.
Manufactured by the Pennsylvania Trojan Powder Co.
Physical examination:
    Diameter of cartridge, 1¾ inches.
    Length of cartridge, 8½ inches.
    Average weight, 506 grams.
    Cartridge had not been redipped.
    Apparent specific gravity of cartridge by sand, 1.40.
    Color of explosive, white.
    Consistency, powdered, very fine, very dry, very soft, not cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, October 18, 1911.
Unit swing on this date, 3.30 inches.
Weight of charge, in grams, 400, 400, 400.
Swing, in inches, 3.40, 3.33, 3.31.
Average swing, in inches, 3.35.

$$3.35 : 3.30 :: 400 : (394).$$

Therefore the unit deflective charge of Trojan coal powder II is 394 grams.

GAS AND DUST GALLERY No. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Oct. 19	394	8.35	No ignition.
Do	394	8.39	Do.
Do	394	8.40	Do.
Do	394	8.12	Do.
Do	394	7.83	Do.
Do	394	7.91	Do.
Do	394	7.90	Do.
Oct. 20	394	8.02	Do.
Do	394	8.35	Do.
Oct. 21	394	8.06	Do.
TEST 3.			
Nov. 3	394	....	No ignition.
Do	394	....	Do.
Do	394	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Nov. 3	394	....	No ignition.
Do	394	....	Do.
Do	394	....	Do.
Do	394	....	Do.
Do	394	....	Do.
Do	394	....	Do.
Do	394	....	Do.
TEST 4.			
Oct. 24	[a] 680	4.17	No ignition.
Do	[a] 680	4.34	Do.
Do	[a] 680	4.17	Do.
Do	[a] 680	4.16	Do.
Do	[a] 680	3.90	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Oct. 18	15.60	44.0	2,821
Do	15.25	44.0	2,885
Do	15.12	44.0	2,910

Average rate of detonation, 2,872 meters (9,420 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 7	19.50	24.63	10.25	0.513
Do	18.00	22.74	9.00	.450
Do	15.75	19.89	8.00	.400

Average height of flame, 22.42 inches.
Average duration of flame, 0.454 millisecond.

IMPACT TEST.

Date, February 21, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	15	2	No explosion.
10	1	No explosion.	15	1	Explosion.
15	1	Do.	14	2	No explosion.
18	1	Explosion.	14	1	Explosion.
17	1	Do.	13	1	Do.
16	1	Do.	12	5	No explosion.

The maximum height at which no explosion occurs established at 12 centimeters (4.72 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 225 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Mar. 18	4	Did not explode.	Mar. 18	3	Did not explode.
Do	2	Exploded.	Do	3	Do.
Do	3	Did not explode.			

The minimum distance at which no explosion occurs established at 3 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.60 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
		Grams.	*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 29	207.2	1.40	23.75	39.58	A	39.30
Do	207.2	1.40	24.00	40.00	A	
Mar. 1	207.2	1.40	23.00	38.33	A	
Feb. 29	207.2	1.40	22.75	37.92	B	37.92
Do	207.2	1.40	23.25	38.75	B	
Do	207.2	1.40	22.25	37.08	B	
Do	207.2	1.40	21.75	36.25	C	36.39
Do	207.2	1.40	22.00	36.67	C	
Do	207.2	1.40	21.75	36.25	C	

[a] Including 7.2 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=42.72$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.40$. $W=207.2$ grams.

$M=\frac{VPS}{W}=4{,}330$ kilograms per square centimeter (61,590 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 7 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, November 24, 1911.

	Grams.
Solid	93.9
Liquid (water)	9.4
Gaseous	92.8

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 103.6 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Feb. 13	81.95	0.768	684.8
Do	81.95	.734	654.1
Do	81.95	.749	667.7

[a] Including 3.6 grams of the original wrapper.

Average large calories per kilogram of explosive, 668.9.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 27	63.50	47.50	16.00
Do	63.50	48.00	15.50
Do	63.50	48.25	15.25

Average compression, 15.6 millimeters (0.61 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912.)	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Feb. 21	62	170	108	15
Do	62	168	106	15
Do	62	170	108	15

Average expansion of bore hole, 107 cubic centimeters (6.53 cubic inches).

TROJAN COAL POWDER I.

Explosive, Trojan coal powder I.
Class 3, organic nitrate.
Manufactured by the Pennsylvania Trojan Powder Co.
Physical examination:
- Diameter of cartridge, 1¼ inches.
- Length of cartridge, 8½ inches.
- Average weight, 501 grams.
- Cartridge had not been redipped.
- Apparent specific gravity of cartridge by sand, 1.38.
- Color of explosive, white.
- Consistency, powdered; very fine, very dry, very soft, not cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, October 18, 1911.
Unit swing used on this date, 3.30 inches.
Weight of charge, in grams, 400, 400, 400.
Swing, in inches, 3.22, 3.24, 3.20.
Average swing, in inches, 3.22.

$$3.22 : 3.30 :: 400 : (410).$$

Therefore the unit deflective charge of the Trojan coal powder I is 410 grams.

GAS AND DUST GALLERY NO. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Oct. 21	410	8.31	No ignition.
Do	410	8.33	Do.
Do	410	7.99	Do.
Do	410	7.96	Do.
Do	410	7.88	Do.
Do	410	8.01	Do.
Do	410	8.16	Do.
Oct. 23	410	8.15	Do.
Do	410	7.95	Do.
Do	410	7.98	Do.
TEST 3.			
Nov. 2	410		No ignition.
Do	410		Do.
Do	410		Do.
TEST 3—Con.			
	Grams.	*Per cent.*	
Nov. 3	410		No ignition.
Do	410		Do.
Do	410		Do.
Do	410		Do.
Do	410		Do.
Do	410		Do.
Do	410		Do.
TEST 4.			
Oct. 24	[a] 680	4.01	No ignition.
Do	[a] 680	4.35	Do.
Do	[a] 680	4.14	Do.
Oct. 25	[a] 680	4.22	Do.
Do	[a] 680	4.08	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Oct. 19	15.20	44.0	2,895
Do	14.80	44.0	2,973
Oct. 20	15.00	44.0	2,933

Average rate of detonation, 2,934 meters (9,620 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 7	17.00	21.47	8.00	0.400
Do	18.00	22.74	8.00	.400
Do	16.50	20.84	9.00	.450

Average height of flame, 21.68 inches.
Average duration of flame, 0.417 millisecond.

IMPACT TEST.

Date, February 21, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
12	1	No explosion.	21	2	No explosion.
15	1	Do.	21	1	Explosion.
18	1	Do.	20	5	No explosion.
22	1	Explosion.			

The maximum height at which no explosion occurs established at 20 centimeters (7.87 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 222 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Mar. 6	3	Did not explode.	Mar. 6	4	Did not explode.
Do	2	Exploded.	Mar. 7	4	Do.
Do	3	Do.	Do	4	Do.

The minimum distance at which no explosion occurs established at 4 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.60 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Mar. 1	208	1.38	26.50	44.17	A	44.17
Do	208	1.38	26.50	44.17	A	
Do	208	1.38	26.50	44.17	A	
Do	208	1.38	23.75	39.58	B	39.30
Do	208	1.38	23.75	39.58	B	
Mar. 2	208	1.38	23.25	38.75	B	
Do	208	1.38	23.00	38.33	C	37.50
Mar. 4	208	1.38	22.50	37.50	C	
Do	208	1.38	22.00	36.67	C	

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[a] Including 8 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=51.15$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.38$. $W=208$ grams.

$M=\frac{VPS}{W}=5{,}090$ kilograms per square centimeter (72,400 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 8 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, December 5, 1911.	Grams.
Solid	84.8
Liquid (water)	10.8
Gaseous	92.1

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 104.0 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*°C.*	*Calories.*
Feb. 17	81.95	0.873	776.6
Do	81.95	.882	784.7
Feb. 19	81.95	.916	815.3

[a] Including 4 grams of the original wrapper.

Average large calories per kilogram of explosive, 792.2.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 27	63.50	48.75	14.75
Do	63.50	49.25	14.25
Do	63.50	49.25	14.25

Average compression, 14.4 millimeters (0.57 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Feb. 21	62	168	106	15
Do	62	164	102	15
Do	62	166	104	15

Average expansion of bore hole, 104 cubic centimeters (6.34 cubic inches).

TROJAN COAL POWDER J.

Explosive, Trojan coal powder J.
Class 3, organic nitrate.
Manufactured by the Pennsylvania Trojan Powder Co.
Physical examination:
  Diameter of cartridge, 1¾ inches.
  Length of cartridge, 8¼ inches.
  Average weight, 471 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.29.
  Color of explosive, white.
  Consistency, powdered, very fine, very dry, very soft, not cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, October 18, 1911.
Unit swing on this date, 3.30 inches.
Weight of charge, in grams, 350, 350, 350.
Swing, in inches, 3.14, 3.21, 3.28.
Average swing, in inches, 3.21.

$$3.21 : 3.30 :: 350 : (360).$$

Therefore the unit deflective charge of Trojan coal powder J is 360 **grams.**

GAS AND DUST GALLERY No. 1.

Date (1911).	Weight of charge.	Methane and ethane.	Result.	Date (1911).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Oct. 23	360	7.93	No ignition.	Nov. 2	360	....	No ignition.
Do	360	7.99	Do.	Do	360	....	Do.
Do	360	8.06	Do.	Do	360	....	Do.
Do	360	8.05	Do.	Do	360	....	Do.
Do	360	8.14	Do.	Do	360	....	Do.
Do	360	8.17	Do.	Do	360	....	Do.
Do	360	8.12	Do.	Do	360	....	Do.
Do	360	7.80	Do.				
Do	360	7.86	Do.	TEST 4.			
Do	360	7.82	Do.				
				Oct. 25	[a] 680	3.98	No ignition.
TEST 3.				Do	[a] 680	3.94	Do.
				Do	[a] 680	4.18	Do.
Nov. 2	360	....	No ignition.	Do	[a] 680	3.95	Do.
Do	360	....	Do.	Do	[a] 680	4.06	Do.
Do	360	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1911).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Oct. 20	13.74	44.0	3,202
Do	13.40	44.0	3,284
Do	13.73	44.0	3,205

Average rate of detonation, 3,230 meters (10,590 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Mar. 7	20.50	25.89	10.50	0.525
Do	17.00	21.47	8.50	.425
Do	22.00	27.79	11.50	.575

Average height of flame, 25.05 inches.
Average duration of flame, 0.508 millisecond.

IMPACT TEST.

Date, February 23, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
20	1	Explosion.	15	1	No explosion.
15	1	No explosion.	15	1	Explosion.
18	1	Do.	14	1	Do.
19	1	Explosion.	13	2	No explosion.
18	1	Do.	13	1	Explosion.
17	1	No explosion.	12	1	Do.
17	1	Explosion.	11	5	No explosion.
16	1	Do.			

The maximum height at which no explosion occurs established at 11 centimeters (4.33 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 207 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Mar. 9	3	Exploded.	Mar. 9	5	Did not explode.
Do.	4	Did not explode.	Mar. 12	5	Do.
Do.	4	Do.	Do.	5	Do.
Do.	4	Exploded.			

The minimum distance at which no explosion occurs established at 5 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.60 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Mar. 6	208	1.29	30.50	50.83	A	50.00
Do.	208	1.29	30.50	50.83	A	
Do.	208	1.29	29.00	48.33	A	
Mar. 5	208	1.29	26.75	44.58	B	45.00
Do.	208	1.29	26.50	44.17	B	
Mar. 6	208	1.29	27.75	46.25	B	
Mar. 7	208	1.29	27.00	45.00	C	45.00
Do.	208	1.29	27.25	45.42	C	
Do.	208	1.29	26.75	44.58	C	

[a] Including 8 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=54.56$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.29$. $W=208$ grams.

$M=\frac{VPS}{W}=5{,}076$ kilograms per square centimeter (72,200 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 8 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, December 6, 1911.

	Grams.
Solid	81.7
Liquid (water)	14.5
Gaseous	97.1

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 104.0 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°C.	*Calories.*
Feb. 19	81.95	0.792	703.7
Do	81.95	.804	714.5
Do	81.95	.827	735.2

[a] Including 4 grams of the original wrapper.

Average large calories per kilogram of explosive, 717.8.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 27	63.50	47.50	16.00
Do	63.50	48.00	15.50
Do	63.50	48.00	15.50

Average compression, 15.7 millimeters (0.62 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°C.
Feb. 23	62	190	128	15
Do	62	186	124	15
Do	62	192	130	15

Average expansion of bore hole, 127 cubic centimeters (7.75 cubic inches).

TUNNELITE B.

Explosive, Tunnelite B.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the G. R. McAbee Powder & Oil Co.
Physical examination:
  Diameter of cartridge, 1¼ inches.
  Length of cartridge, 8 inches.
  Average weight, 164 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 0.94.
  Color of explosive, corn.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, April 15, 1912.

Unit swing on this date, 3.37 inches.

Weight of charge, in grams, 240, 240, 240.

Swing, in inches, 3.23, 3.28, 3.23.

Average swing, in inches, 3.25.

3.25 : 3.37 : : 240 : (249).

Therefore the unit deflective charge of Tunnelite B is 249 grams.

GAS AND DUST GALLERY NO. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Apr. 16	249	8.46	No ignition.
Do	249	8.37	Do.
Do	249	8.39	Do.
Apr. 17	249	8.07	Do.
Do	249	8.22	Do.
Do	249	8.43	Do.
Do	249	8.25	Do.
Do	249	8.10	Do.
Do	249	8.34	Do.
Do	249	8.14	Do.
TEST 3.			
Apr. 24	249	....	No ignition.
Do	249	....	Do.
Do	249	....	Do.
TEST 3—Con.			
Apr. 24	249	....	No ignition.
Do	249	....	Do.
Do	249	....	Do.
Do	249	....	Do.
Do	249	....	Do.
Do	249	....	Do.
Do	249	....	Do.
TEST 4.			
Apr. 23	[a] 680	4.04	No ignition.
Do	[a] 680	4.18	Do.
Do	[a] 680	4.18	Do.
Do	[a] 680	4.17	Do.
Do	[a] 680	4.04	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.

Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
May 2	15.05	45.0	2,990
Do	14.45	44.5	3,080
Do	14.65	45.0	3,072

Average rate of detonation, 3,047 meters (9,990 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Sept. 7	7.50	9.47	2.00	0.100
Sept. 10	6.25	7.89	1.50	.075
Do	5.75	7.26	1.00	.050

Average height of flame, 8.21 inches.

Average duration of flame, 0.075 millisecond.

IMPACT TEST.

Date, September 6, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
25	1	No explosion.	15	1	Explosion.
30	1	Explosion.	10	1	No explosion.
27	1	Do.	14	1	Explosion.
25	1	Do.	13	5	No explosion.
20	1	Do.			

The maximum height at which no explosion occurs established at 13 centimeters (5.12 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 151 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Sept. 6	3	Did not explode.	Sept. 6	2	Exploded.
Do	2	Do.	Do	3	Did not explode.
Do	1	Exploded.	Do	3	Do.

The minimum distance at which no explosion occurs established at 3 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Aug. 8	219	0.94	30.00	93.75	A	94.53
Do	219	.94	30.00	93.75	A	
Do	219	.94	30.75	96.09	A	
Aug. 7	219	.94	28.00	87.50	B	88.54
Do	219	.94	28.25	88.28	B	
Do	219	.94	28.75	89.84	B	
Aug. 6	219	.94	28.00	87.50	C	87.50
Aug. 7	219	.94	28.25	88.28	C	
Do	219	.94	27.75	86.72	C	

[a] Including 19 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=101.45$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=0.94$. $W=219$ grams.

$M=\frac{VPS}{W}=6{,}532$ kilograms per square centimeter (92,910 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 19 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, April 29, 1912.	Grams.
Solid	24.6
Liquid (water)	63.0
Gaseous	126.1

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 109.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	°C.	*Calories.*
July 24	81.95	1.100	931.4
Do	81.95	1.108	938.3
July 25	81.95	1.120	948.5

[a] Including 9.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 939.4.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Sept. 24	63.25	49.75	13.50
Do	63.25	49.75	13.50
Do	63.25	50.00	13.25

Average compression, 13.4 millimeters (0.53 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°C.
Sept. 21	62	306	244	16
Do	62	305	243	16
Do	62	312	250	16

Average expansion of bore hole, 246 cubic centimeters (15.01 cubic inches).

TUNNELITE C.

Explosive, Tunnelite C.
Class 1*a*, ammonium nitrate, containing nitroglycerin.
Manufactured by the G. R. McAbee Powder & Oil Co.
Physical examination:
    Diameter of cartridge, 1¼ inches.
    Length of cartridge, 8 inches.
    Average weight, 178 grams.
    Cartridge had been redipped.
    Apparent specific gravity of cartridge by sand, 1.02.
    Color of explosive, corn.
    Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, April 15, 1912.
Unit swing on this date, 3.37 inches.
Weight of charge, in grams, 250, 250, 250.
Swing, in inches, 3.25, 3.40, 3.24.
Average swing, in inches, 3.30.

3.30 : 3.37 : : 250 : (255).

Therefore the unit deflective charge of Tunnelite C is 255 grams.

GAS AND DUST GALLERY No. 1.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
TEST 1.			
	Grams.	*Per cent.*	
Apr. 17	255	8.07	No ignition.
Do	255	7.87	Do.
Do	255	7.77	Do.
Do	255	7.87	Do.
Do	255	8.51	Do.
Do	255	7.97	Do.
Do	255	7.97	Do.
Do	255	8.33	Do.
Apr. 18	255	8.36	Do.
Do	255	8.09	Do.
TEST 3.			
Apr. 24	255	....	No ignition.
Do	255	....	Do.
Do	255	....	Do.
TEST 3—Con.			
Apr. 24	255	....	No ignition.
Do	255	....	Do.
Do	255	....	Do.
Do	255	....	Do.
Do	255	....	Do.
Do	255	....	Do.
Do	255	....	Do.
TEST 4.			
Apr. 23	[a] 680	4.06	No ignition.
Do	[a] 680	4.17	Do.
Do	[a] 680	4.20	Do.
Do	[a] 680	4.19	Do.
Do	[a] 680	4.22	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
May 2	14.80	45.0	3,041
May 3	14.35	44.5	3,101
Do	14.20	43.5	3,063

Average rate of detonation, 3,068 meters (10,060 feet) per second.

IMPACT TEST.

Date, August 19, 1912.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
40	1	No explosion.	65	1	Explosion.
50	1	Do.	62	1	No explosion.
60	1	Do.	64	5	Do.
70	1	Explosion.			

The maximum height at which no explosion occurs established at 64 centimeters (25.2 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 164 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Sept. 7	3	Did not explode.	Sept. 7	2	Exploded.
Do	2	Do.	Do	3	Did not explode.
Do	1	Exploded.	Do	3	Do.

The minimum distance at which no explosion occurs established at 3 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1912).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Aug. 19	218	1.02	30.25	94.53	A	96.61
Do	218	1.02	30.75	96.09	A	
Do	218	1.02	31.75	99.22	A	
Aug. 22	218	1.02	28.00	87.50	B	87.50
Do	218	1.02	28.00	87.50	B	
Do	218	1.02	28.00	87.50	B	
Aug. 21	218	1.02	27.50	85.94	C	85.94
Do	218	1.02	27.75	86.72	C	
Do	218	1.02	27.25	85.16	C	

[a] Including 18 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=107.11$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.02$. $W=218$ grams.

$M=\frac{VPS}{W}=7{,}517$ kilograms per square centimeter (106,920 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 19 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, April 30, 1912.	Grams.
Solid	24.7
Liquid (water)	61.5
Gaseous	125.2

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 109.0 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
July 25	81.95	1.139	969.2
Do	81.95	1.100	935.7
Do	81.95	1.100	935.7

[a] Including 9 grams of the original wrapper.

Average large calories per kilogram of explosive, 946.9.

Compression of Small Lead Blocks.

Charge, 100 grams.

Date (1912).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Aug. 14	63.25	48.75	14.50
Aug. 15	63.25	48.50	14.75
Do	63.50	49.25	14.25

Average compression, 14.5 millimeters (0.57 inch).

Expansion of Bore Hole of Trauzl Lead Blocks.

Charge, 10 grams.

Date (1912).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Sept. 27	62	270	208	15
Do	62	272	210	15
Do	62	277	215	15

Average expansion of bore hole, 211 cubic centimeters (12.87 cubic inches).

TUNNELITE NO. 5.

Explosive, Tunnelite No. 5.
Class 4, nitroglycerin.
Manufactured by the G. R. McAbee Powder & Oil Co.
Physical examination:
  Diameter of cartridge, 1½ inches.
  Length of cartridge, 8 inches.
  Average weight, 220 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.06.
  Color of explosive, ecru with green spots.
  Consistency, granular, fine, dry, soft, slightly cohesive.
 Unit deflective charge as determined by the ballistic pendulum:
  Date, August 27, 1909.
  Unit swing on this date, 2.61 inches.
  Weight of charge, in grams, 315, 315, 315.
  Swing, in inches, 2.55, 2.54, 2.45.
  Average swing, in inches, 2.51.

2.51 : 2.61 : : 315 : (328).

Therefore the unit deflective charge of Tunnelite No. 5 is 328 grams.

GAS AND DUST GALLERY No. 1.

Date (1909).	Weight of charge.	Methane and ethane.	Result.	Date (1909).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Aug. 31	328	8.21	No ignition.	Sept. 1	328	....	No ignition.
Do	328	8.41	Do.	Do	328	....	Do.
Do	328	8.51	Do.	Do	328	....	Do.
Do	328	8.60	Do.	Do	328	....	Do.
Do	328	8.16	Do.	Do	328	....	Do.
Do	328	8.45	Do.	Do	328	....	Do.
Do	328	8.50	Do.	Do	328	....	Do.
Do	328	8.45	Do.	TEST 4.			
Do	328	8.45	Do.				
Sept. 2	328	8.33	Do.				
				Aug. 13	[a] 680	4.35	No ignition.
TEST 3.				Do	[a] 680	4.16	Do.
				Do	[a] 680	4.16	Do.
Aug. 31	328	....	No ignition.	Do	[a] 680	3.92	Do.
Sept. 1	328	....	Do.	Do	[a] 680	4.00	Do.
Do	328	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1909–10).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Aug. 27	16.90	43.0	2,544
Aug. 28	16.60	43.0	2,590
June 2	16.85	43.0	2,552

Average rate of detonation, 2,562 meters (8,400 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 12	19.50	24.63	8.50	0.425
Do	11.25	14.21	6.50	.325
Do	16.50	20.84	7.75	.388

Average height of flame, 19.89 inches.
Average duration of flame, 0.379 millisecond.

IMPACT TEST.

Date, May 5, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
14	1	No explosion	13	1	Explosion.
18	1	Explosion.	12	1	No explosion.
16	1	Do.	12	1	Explosion.
15	1	Do.	11	1	Do.
14	3	No explosion.	10	5	No explosion.
14	1	Explosion.			

The maximum height at which no explosion occurs established at 10 centimeters (3.94 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 180 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Dec. 3	10	Exploded.	Dec. 4	16	Did not explode.
Dec. 4	12	Do.	Do	16	Exploded.
Do	14	Did not explode.	Do	17	Did not explode.
Do	13	Exploded.	Do	17	Exploded.
Do	14	Do.	Do	18	Did not explode.
Do	15	Did not explode.	Do	18	Exploded.
Do	15	Do.	Do	19	Did not explode.
Do	15	Exploded.	Do	19	Do.
Do	16	Did not explode.	Do	19	Do.

The minimum distance at which no explosion occurs established at 19 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Jan. 31	213	1.12	19.75	61.72	A	62.24
Do	213	1.12	20.00	62.50	A	
Do	213	1.12	20.00	62.50	A	
Do	213	1.12	20.00	62.50	B	61.46
Do	213	1.12	19.75	61.72	B	
Feb. 13	213	1.12	19.25	60.16	B	
Jan. 31	213	1.12	18.50	57.81	C	57.03
Do	213	1.12	18.00	56.25	C	
Do	213	1.12	18.25	57.03	C	

[a] Including 13 grams of the original wrapper.

$P = 1.911A + 0.5B - 1.411C = 69.20$ kilograms per square centimeter.

$V = 15{,}000$ cubic centimeters. $S = 1.12$. $W = 213$ grams.

$M = \frac{VPS}{W} = 5{,}458$ kilograms per square centimeter (77,630 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 13 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 15, 1910.

	Grams.
Solid	82. 9
Liquid (water)	12. 1
Gaseous	113. 8

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Dec. 12	81. 95	0. 786	682. 0
Do	81. 95	. 771	668. 8
Do	81. 95	. 791	686. 4

[a] Including 6.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 679.1.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
June 2	63. 50	54. 25	9. 25
Do	63. 50	54. 00	9. 50
Do	63. 50	54. 25	9. 25

Average compression, 9.3 millimeters (0.37 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
May 26	63	183	120	15
Do	63	186	123	15
Do	63	188	125	15

Average expansion of bore hole, 123 cubic centimeters (7.50 cubic inches).

TUNNELITE NO. 6.

Explosive, Tunnelite No. 6.
Class 4, nitroglycerin.
Manufactured by the G. R. McAbee Powder & Oil Co.
Physical examination:
  Diameter of cartridge, 1½ inches.
  Length of cartridge, 8 inches.
  Average weight, 202 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 0.97.
  Color of explosive, Nile green.
  Consistency, granular, fine, dry, soft, moderately cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, August 27, 1909.
  Unit swing on this date, 2.61 inches.
  Weight of charge, in grams, 305, 305, 305.
  Swing, in inches, 2.57, 2.58, 2.67.
  Average swing, in inches, 2.61.
  2.61 : 2.61 : : 305 : (305).
Therefore the unit deflective charge of Tunnelite No. 6 is 305 grams.

GAS AND DUST GALLERY NO. 1.

Date (1909).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Sept. 2	305	7.93	No ignition.
Do	305	8.30	Do.
Do	305	8.04	Do.
Do	305	8.20	Do.
Do	305	8.21	Do.
Do	305	8.30	Do.
Do	305	8.28	Do.
Do	305	8.33	Do.
Do	305	8.06	Do.
Do	305	8.21	Do.
TEST 3.			
Sept. 2	305	....	No ignition.
Do	305	....	Do.
Sept. 3	305	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Sept. 3	305	....	No ignition.
Do	305	....	Do.
Do	305	....	Do.
Do	305	....	Do.
Do	305	....	Do.
Do	305	....	Do.
Do	305	....	Do.
TEST 4.			
Sept. 1	[a]680	4.20	No ignition.
Do	[a]680	4.53	Do.
Do	[a]680	4.32	Do.
Do	[a]680	4.26	Do.
Do	[a]680	4.37	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1909).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
June 6	14.46	43.0	2,974
June 7	14.78	43.0	2,909
Do	14.54	43.0	2,957

Average rate of detonation, 2,947 meters (9,670 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 12	25.00	31.58	12.00	0.600
Do	18.00	22.74	8.50	.425
Do	20.00	25.26	8.50	.425

Average height of flame, 26.53 inches.

Average duration of flame, 0.483 millisecond.

IMPACT TEST.

Date, May 6, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
12	1	No explosion.	14	1	Explosion.
14	1	Do.	13	1	Do.
16	1	Explosion.	12	1	Do.
15	1	Do.	11	5	No explosion.

The maximum height at which no explosion occurs established at 11 centimeters (4.33 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 167 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Dec. 3	5	Exploded.	Dec. 3	13	Exploded.
Do	9	Do.	Do	14	Do.
Do	12	Do.	Do	15	Did not explode.
Do	14	Did not explode.	Do	15	Do.
Do	13	Do.	Do	15	Do.

The minimum distance at which no explosion occurs established at 15 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Jan. 31	213	1.04	21.75	67.97	A	67.19
Do	213	1.04	21.75	67.97	A	
Feb. 1	213	1.04	21.00	65.62	A	
Do	213	1.04	20.50	64.06	B	64.06
Do	213	1.04	20.75	64.84	B	
Do	213	1.04	20.25	63.28	B	
Feb. 3	213	1.04	19.75	61.72	C	62.24
Do	213	1.04	20.00	62.50	C	
Do	213	1.04	20.00	62.50	C	

[a] Including 13 grams of the original wrapper.

$P = 1.911A + 0.5B - 1.411C = 72.61$ kilograms per square centimeter.

$V = 15{,}000$ cubic centimeters. $S = 1.04$. $W = 213$ grams.

$M = \frac{VPS}{W} = 5{,}318$ kilograms per square centimeter (75,640 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 14 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 18, 1910.	Grams.
Solid	67.1
Liquid (water)	14.4
Gaseous	122.4

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.5 grams.[a]

Date (1912).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Dec. 13	81.95	0.794	689.0
Do	81.95	.776	673.2
Dec. 16	81.95	.773	670.6

[a] Including 6.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 677.6.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
June 2	63.50	52.25	11.25
Do	63.50	51.75	11.75
Do	63.50	51.50	12.00

Average compression, 11.7 millimeters (0.46 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
May 26	63	222	159	15
Do	63	218	155	15
Do	63	213	150	15

Average expansion of bore hole, 155 cubic centimeters (9.46 cubic inches).

TUNNELITE NO. 6–L. F.

Explosive, Tunnelite No. 6–L. F.
Class 4, nitroglycerin.
Manufactured by the G. R. McAbee Powder & Oil Co.
Physical examination:
- Diameter of cartridge, 1⅜ inches.
- Length of cartridge, 8 inches.
- Average weight, 214 grams.
- Cartridge had not been redipped.
- Apparent specific gravity of cartridge by sand, 1.02.
- Color of explosive, ecru with green spots.
- Consistency, fibrous, coarse, dry, hard, moderately cohesive.

Unit deflective charge as determined by the ballistic pendulum:
- Date, December 13, 1909.
- Unit swing on this date, 3.14 inches.
- Weight of charge, in grams, 305, 305, 305.
- Swing, in inches, 3.23, 3.18, 3.13.
- Average swing, in inches, 3.18.

3.18 : 3.14 : : 305 : (301).

Therefore the unit deflective charge of Tunnelite No. 6–L. F. is 301 grams.

GAS AND DUST GALLERY NO. 1.

Date (1909–10).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Dec. 21	301	7.78	No ignition.
Do	301	7.81	Do.
Do	301	7.81	Do.
Dec. 22	301	8.16	Do.
Do	301	8.16	Do.
Do	301	7.98	Do.
Do	301	8.16	Do.
Do	301	8.16	Do.
Do	301	8.16	Do.
Do	301	8.07	Do.
TEST 3.			
Jan. 26	301	....	No ignition.
Do	301	....	Do.
Do	301	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Jan. 26	301	....	No ignition.
Do	301	....	Do.
Do	301	....	Do.
Do	301	....	Do.
Do	301	....	Do.
Do	301	....	Do.
Do	301	....	Do.
TEST 4.			
Jan. 20	[a] 680	3.98	No ignition.
Do	[a] 680	4.09	Do.
Jan. 21	[a] 680	4.14	Do.
Do	[a] 680	3.90	Do.
Do	[a] 680	3.90	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1909).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Dec. 15	14.92	43.0	2,882
Dec. 17	14.22	43.0	3,024
Do	14.86	43.0	2,894

Average rate of detonation, 2,933 meters (9,620 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Sept. 24	13.75	17.37	6.00	0.300
Do	12.50	15.79	5.50	.275
Do	16.75	21.16	8.25	.412

Average height of flame, 18.11 inches.
Average duration of flame, 0.329 millisecond.

IMPACT TEST.

Date, June 29, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
18	1	No explosion.	27	1	Explosion.
20	1	Do.	26	1	Do.
24	1	Do.	25	5	No explosion.
28	1	Explosion.			

The maximum height at which no explosion occurs established at 25 centimeters (9.84 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 166 grams.

Date (1910).	Distance separating cartridges.	Result, upper cartridge.	Date (1910).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Nov. 19	6	Did not explode.	Nov. 19	4	Did not explode.
Do	4	Do.	Do	4	Do.
Do	3	Exploded.			

The minimum distance at which no explosion occurs established at 4 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

Date (1910).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
June 27	218	1.02	26.75	66.88	A	65.83
Do	218	1.02	26.00	65.00	A	
Do	218	1.02	26.25	65.62	A	
Oct. 4	218	1.02	24.75	61.88	B	61.46
Do	218	1.02	24.50	61.25	B	
Do	218	1.02	24.50	61.25	B	
Do	218	1.02	23.75	59.38	C	60.21
Do	218	1.02	24.25	60.62	C	
Do	218	1.02	24.25	60.62	C	

[a] Including 18 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=71.57$ kilograms per square centimeter.
$V=15{,}000$ cubic centimeters. $S=1.02.$ $W=218$ grams.

$M=\frac{VPS}{W}=5{,}023$ kilograms per square centimeter (71,450 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 18 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, July 1, 1910.

	Grams.
Solid	65.0
Liquid (water)	12.0
Gasecus	132.7

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 110.0 grams.[a]

Date (1910).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Aug. 23	80.95	0.759	630.5
Aug. 24	80.95	.746	619.5
Do	80.95	.736	611.1

[a] Including 10 grams of the original wrapper.

Average large calories per kilogram of explosive, 620.4.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
Mar. 12	63.50	52.75	10.75
Do	63.50	52.75	10.75
Do	63.50	53.50	10.00

Average compression, 10.5 millimeters (0.41 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
Oct. 19	63	214	151	15
Do	63	210	147	15
Do	63	214	151	15

Average expansion of bore hole, 150 cubic centimeters (9.15 cubic inches).

TUNNELITE NO. 7.

Explosive, Tunnelite No. 7.

Class 4, nitroglycerin.

Manufactured by the G. R. McAbee Powder & Oil Co.

Physical examination:

Diameter of cartridge, 1½ inches.

Length of cartridge, 8 inches.

Average weight, 200 grams.

Cartridge had not been redipped.

Apparent specific gravity of cartridge by sand, 0.98.

Color of explosive, ecru with green spots.

Consistency, granular, fine, dry, soft, slightly cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, August 17, 1909.

Unit swing on this date, 2.75 inches.

Weight of charge, in grams, 305, 305, 305.

Swing, in inches, 2.64, 2.68, 2.77.

Average swing, in inches, 2.70.

2.70 : 2.75 : : 305 : (311).

Therefore the unit deflective charge of Tunnelite No. 7 is 311 grams.

GAS AND DUST GALLERY NO. 1.

Date (1909).	Weight of charge.	Methane and ethane.	Result.	Date (1909).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Aug. 20	311	8.45	No ignition.	Aug. 25	311	....	No ignition.
Do	311	8.62	Do.	Do	311	....	Do.
Do	311	8.62	Do.	Do	311	....	Do.
Do	311	8.62	Do.	Aug. 26	311	....	Do.
Aug. 23	311	7.97	Do.	Do	311	....	Do.
Do	311	8.32	Do.	Do	311	....	Do.
Do	311	8.34	Do.	Do	311	....	Do.
Do	311	8.20	Do.				
Do	311	8.19	Do.	TEST 4.			
Do	311	8.40	Do.				
				Aug. 16	[a] 680	4.22	No ignition.
TEST 3.				Do	[a] 680	4.22	Do.
				Do	[a] 680	4.22	Do.
Aug. 25	311	....	No ignition.	Do	[a] 680	4.14	Do.
Do	311	....	Do.	Do	[a] 680	4.22	Do.
Do	311	....	Do.				

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.

Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
June 4	16.18	43.0	2,658
Do	16.17	43.0	2,659
Do	16.16	43.0	2,661

Average rate of detonation, 2,659 meters (8,720 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 12	20.50	25.89	10.00	0.500
Do	18.75	23.68	8.00	.400
Do	18.75	23.68	7.75	.388

Average height of flame, 24.42 inches.
Average duration of flame, 0.429 millisecond.

IMPACT TEST.

Date, May 5, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
14	1	No explosion.	13	3	No explosion.
16	1	Explosion.	13	1	Explosion.
15	1	Do.	12	2	No explosion.
14	1	No explosion.	12	1	Explosion.
14	1	Explosion.	11	5	No explosion.

The maximum height at which no explosion occurs established at 11 centimeters (4.33 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 164 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Dec. 4	14	Did not explode.	Dec. 5	15	Did not explode.
Do	12	Do.	Do	15	Exploded.
Dec. 5	10	Exploded.	Do	16	Do.
Do	11	Do.	Do	17	Did not explode.
Do	12	Do.	Do	17	Do
Do	13	Do.	Do	17	Do.
Do	14	Do.			

The minimum distance at which no explosion occurs established at 17 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 4	211	1.02	20.50	64.06	A	62.76
Do	211	1.02	20.25	63.28	A	
Do	211	1.02	19.50	60.94	A	
Feb. 3	211	1.02	19.50	60.94	B	60.68
Do	211	1.02	19.50	60.94	B	
Do	211	1.02	19.25	60.16	B	
Do	211	1.02	18.00	56.25	C	57.29
Do	211	1.02	18.25	57.03	C	
Do	211	1.02	18.75	58.59	C	

[a] Including 11 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=69.44$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.02$. $W=211$ grams.

$M=\frac{VPS}{W}=5{,}035$ kilograms per square centimeter (71,610 pounds per square inch).

Products of Combustion from 200 Grams of the Explosive and 11 Grams of the Original Wrapper.

[Analyst, A. L. Hyde.]

Date, December 12, 1912.	Grams.
Solid	52.0
Liquid (water)	10.0
Gaseous	123.8

Large Calories Developed by 1 Kilogram of the Explosive.

Charge, 105.5 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*° C.*	*Calories.*
Jan. 10	81.95	0.697	609.6
Do	81.95	.714	624.6
Jan. 11	81.95	.722	631.8

[a] Including 5.5 grams of the original wrapper.

Average large calories per kilogram of explosive, 622.0.

Compression of Small Lead Blocks.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
June 2	63.50	53.50	10.00
Do	63.50	53.00	10.50
Do	63.50	51.75	11.75

Average compression, 10.8 millimeters (0.43 inch).

Expansion of Bore Hole of Trauzl Lead Blocks.

Charge, 10 grams.

Date (1910)	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
May 26	63	212	149	15
Do	63	209	146	15
Do	63	208	145	15

Average expansion of bore hole, 147 cubic centimeters (8.97 cubic inches).

TUNNELITE NO. 8.

Explosive, Tunnelite No. 8.
Class 4, nitroglycerin.
Manufactured by the G. R. McAbee Powder & Oil Co.
Physical examination:
  Diameter of cartridge, 1½ inches.
  Length of cartridge, 8 inches.
  Average weight, 209 grams.
  Cartridge had not been redipped.
  Apparent specific gravity of cartridge by sand, 1.00.
  Color of explosive, ecru with green spots.
  Consistency, granular, fine, dry, soft, slightly cohesive.
Unit deflective charge as determined by the ballistic pendulum:
  Date, August 17, 1909.
  Unit swing on this date, 2.75 inches.
  Weight of charge, grams, 310, 310, 310.
  Swing, in inches, 2.60, 2.62, 2.67.
  Average swing, in inches, 2.63.

$$2.63 : 2.75 :: 310 : (324).$$

Therefore the unit deflective charge of Tunnelite No. 8 is 324 grams.

GAS AND DUST GALLERY No. 1.

Date (1909).	Weight of charge.	Methane and ethane.	Result.
TEST 1.	*Grams.*	*Per cent.*	
Aug. 23	324	8.29	No ignition.
Do.	324	8.37	Do.
Do.	324	8.59	Do.
Do.	324	8.36	Do.
Do.	324	8.54	Do.
Aug. 24	324	8.02	Do.
Do.	324	8.40	Do.
Do.	324	8.26	Do.
Do.	324	8.20	Do.
Do.	324	8.56	Do.
TEST 3.			
Aug. 24	324	....	No ignition.
Do.	324	....	Do.
Do.	324	....	Do.
TEST 3—Con.	*Grams.*	*Per cent.*	
Aug. 24	324	....	No ignition.
Do.	324	....	Do.
Do.	324	....	Do.
Do.	324	....	Do.
Do.	324	....	Do.
Do.	324	....	Do.
Do.	324	....	Do.
TEST 4.			
Aug. 13	[a] 680	4.16	No ignition.
Aug. 14	[a] 680	4.25	Do.
Do.	[a] 680	4.25	Do.
Do.	[a] 680	4.16	Do.
Do.	[a] 680	4.25	Do.

[a] 680 grams or more was used.

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.
Electric detonator, No. 7.

Date (1910).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
June 6	17.23	43.0	2,496
Do.	18.05	43.0	2,382
Do.	17.49	43.0	2,459

Average rate of detonation, 2,446 meters (8,020 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Apr. 12	16.00	20.21	9.75	0.488
Do	15.50	19.58	6.50	.325
Do	21.75	27.47	11.75	.588

Average height of flame, 22.42 inches.
Average duration of flame, 0.467 millisecond.

IMPACT TEST.

Date, May 6, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
12	1	No explosion.	11	1	Explosion.
14	1	Explosion.	10	1	No explosion.
13	1	Do.	10	1	Explosion.
12	1	Do.	9	1	Do.
11	2	No explosion.	8	5	No explosion.

The maximum height at which no explosion occurs established at 8 centimeters (3.15 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 172 grams.

Date (1912).	Distance separating cartridges.	Result, upper cartridge.	Date (1912).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Dec. 5	15	Exploded.	Dec. 5	18	Did not explode.
Do	17	Do.	Do	18	Do.
Do	18	Did not explode.			

The minimum distance at which no explosion occurs established at 18 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Date (1913).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
Feb. 4	212	1.07	20.25	63.28	A	62.50
Do	212	1.07	20.00	62.50	A	
Do	212	1.07	19.75	61.72	A	
Do	212	1.07	18.75	58.59	B	59.64
Do	212	1.07	19.25	60.16	B	
Feb. 13	212	1.07	19.25	60.16	B	
Feb. 4	212	1.07	18.50	57.81	C	59.12
Feb. 5	212	1.07	19.25	60.16	C	
Do	212	1.07	19.00	59.38	C	

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[a] Including 12 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=65.84$ kilograms per square centimeter.
$V=15{,}000$ cubic centimeters. $S=1.07$. $W=212$ grams.

$$M=\frac{VPS}{W}=4{,}985$$ kilograms per square centimeter (70,900 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 14 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst, A. L. Hyde.]

Date, June 17, 1910.

	Grams.
Solid	78.5
Liquid (water)	16.0
Gaseous	116.4

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 106.0 grams.[a]

Date (1913).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	*°C.*	*Calories.*
Jan. 18	81.95	0.790	688.8
Do	81.95	.803	700.2
Jan. 20	81.95	.768	669.3

[a] Including 6 grams of the original wrapper.

Average large calories per kilogram of explosive, 686.1.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before explosion.	After explosion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
June 2	63.50	53.50	10.00
Do	63.50	53.25	10.25
Do	63.50	53.50	10.00

Average compression, 10.1 millimeters (0.40 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	*°C.*
May 26	63	188	125	15
Do	63	199	136	15
Do	63	199	136	15

Average expansion of bore hole, 132 cubic centimeters (8.05 cubic inches).

TUNNELITE NO. 8–L. F.

Explosive, Tunnelite No. 8–L. F.

Class 4, nitroglycerin.

Manufactured by the G. R. McAbee Powder & Oil Co.

Physical examination:

Diameter of cartridge, 1⅜ inches.

Length of cartridge, 8 inches.

Average weight, 218 grams.

Cartridge had not been redipped.

Apparent specific gravity of cartridge by sand, 1.05.

Color of explosive, ecru with green spots.

Consistency, granular and fibrous, coarse, dry, hard, moderately cohesive.

Unit deflective charge as determined by the ballistic pendulum:

Date, December 13, 1909.

Unit swing on this date, 3.14 inches.

Weight of charge, in grams, 320, 320, 320.

Swing, in inches, 3.18, 3.10, 3.08.

Average swing, in inches, 3.12.

3.12 : 3.14 : : 320 : (322).

Therefore the unit deflective charge of Tunnelite No. 8–L. F. is 322 grams.

Gas and Dust Gallery No. 1.

Date (1909–10).	Weight of charge.	Methane and ethane.	Result.	Date (1910).	Weight of charge.	Methane and ethane.	Result.
TEST 1.				TEST 3—Con.			
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
Dec. 21	322	7.98	No ignition.	Jan. 26	322	....	No ignition.
Do	322	8.32	Do.	Jan. 27	322	....	Do.
Do	322	8.32	Do.	Do	322	....	Do.
Do	322	8.32	Do.	Do	322	....	Do.
Do	322	8.16	Do.	Do	322	....	Do.
Do	322	7.98	Do.	Do	322	....	Do.
Do	322	7.81	Do.	Do	322	....	Do.
Do	322	7.81	Do.				
Do	322	7.81	Do.	TEST 4.			
Do	322	7.81	Do.				
				Jan. 20	[a] 680	4.23	No ignition.
TEST 3.				Do	[a] 680	4.14	Do.
				Do	[a] 680	3.93	Do.
Jan. 26	322	....	No ignition.	Do	[a] 680	3.93	Do.
Do	322	....	Do.	Do	[a] 680	4.14	Do.
Do	322	....	Do.				

[a] 680 grams or more was used.

Rate of Detonation.

Diameter of cartridge, 1¼ inches.

Electric detonator. No. 7.

Date (1909).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
	Millimeters.	*Meters.*	*Meters.*
Dec. 17	16.55	43.0	2,598
Dec. 18	15.96	43.0	2,694
Do	16.03	43.0	2,682

Average rate of detonation, 2,658 meters (8,720 feet) per second.

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Date (1910).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
	Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
Sept. 26	11.00	13.89	5.00	0.250
Sept. 29	9.75	12.32	5.75	.288
Do	13.00	16.42	6.00	.300

Average height of flame, 14.21 inches.

Average duration of flame, 0.279 millisecond.

IMPACT TEST.

Date, June 29, 1910.

Distance of fall.	Number of trials.	Result.	Distance of fall.	Number of trials.	Result.
Centimeters.			*Centimeters.*		
18	1	No explosion.	17	1	Explosion.
22	1	Explosion.	16	1	Do.
20	1	Do.	15	1	No explosion.
19	1	Do.	15	1	Explosion.
18	2	No explosion.	14	1	Do.
18	1	Explosion.	13	5	No explosion.
17	1	No explosion.			

The maximum height at which no explosion occurs established at 13 centimeters (5.12 inches).

EXPLOSION-BY-INFLUENCE TEST.

Weight of each cartridge, 169 grams.

Date (1910).	Distance separating cartridges.	Result, upper cartridge.	Date (1910).	Distance separating cartridges.	Result, upper cartridge.
	Inches.			*Inches.*	
Nov. 20	3	Exploded.	Nov. 21	7	Did not explode.
Nov. 21	4	Do.	Do	7	Do.
Do	6	Do.	Do	7	Do.
Do	8	Did not explode.			

The minimum distance at which no explosion occurs established at 7 inches.

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.4 millimeter=1 kilogram per square centimeter.

Date (1910).	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
	Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
June 28	218	1.05	25.75	64.38	A	62.92
Do	218	1.05	25.00	62.50	A	
Do	218	1.05	24.75	61.88	A	
Oct. 5	218	1.05	23.25	58.12	B	58.75
Do	218	1.05	23.75	59.38	B	
Do	218	1.05	23.50	58.75	B	
Oct. 6	218	1.05	23.50	58.75	C	57.29
Do	218	1.05	22.75	56.88	C	
Do	218	1.05	22.50	56.25	C	

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[a] Including 15 grams of the original wrapper.

$P=1.911A+0.5B-1.411C=68.78$ kilograms per square centimeter.

$V=15{,}000$ cubic centimeters. $S=1.05$. $W=218$ grams.

$M=\frac{VPS}{W}=4{,}969$ kilograms per square centimeter (70,680 pounds per square inch).

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 18 GRAMS OF THE ORIGINAL WRAPPER.

[Analyst. A. L. Hyde.]

Date, July 6, 1910.	Grams.
Solid	73.6
Liquid (water)	15.0
Gaseous	129.4

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Charge, 108.4 grams.[a]

Date (1910).	Weight of water.	Rise in temperature.	Heat developed per kilogram.
	Kilograms.	° *C.*	*Calories.*
Aug. 24	80.95	0.742	625.3
Aug. 25	80.95	.757	638.0
Do	80.95	.758	638.9

[a] Including 8.4 grams of the original wrapper.

Average large calories per kilogram of explosive, 634.1.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Date (1910).	Height.		Compression.
	Before expansion.	After expansion.	
	Millimeters.	*Millimeters.*	*Millimeters.*
July 9	63.50	54.25	9.25
Do	63.50	53.75	9.75
Do	63.50	54.00	9.50

Average compression, 9.5 millimeters (0.37 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Date (1910).	Volume of bore hole.		Expansion of bore hole.	Temperature of block.
	Before shot.	After shot.		
	Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*	°*C.*
Oct. 19	63	200	137	15
Do	63	200	137	15
Do	63	200	137	15

Average expansion of bore hole, 137 cubic centimeters (8.36 cubic inches).

RESULTS OF TESTS WITH SIX FOREIGN EXPLOSIVES.

The methods followed at all stations that are testing coal-mining explosives were devised so as to classify explosives with respect to their suitability for use in coal mines. The testing galleries in which explosives are tested vary in size, form, and material. Steel cannon in which the charges of explosives are fired are used at all stations except Austria, the bore of the cannon varying from 40 to 55 millimeters.

Natural gas is used at some stations and artificial substitutes at others. The limit charge established for a given explosive is by no means the same at each station; moreover, in some cases there is even a marked dissimilarity of results.

The use of stemming at foreign stations and at the Pittsburgh experiment station has been found to raise the limit charge considerably, especially of the ammonium nitrate class of explosives.

Air-spacing inside the bore of the cannon, as practiced at most of the Continental stations, is said to extend the apparent border line of safety. However, it may be stated that the results obtained with different charging densities at the Pittsburgh experiment station do not indicate that the border line of safety is necessarily extended with low-charging densities; on the other hand, some explosives have passed the test with a charge of 680 grams when loaded with a charging density of 1 that would not pass with this amount when loaded air spaced.

It has been shown by some of the German stations that some of the permitted explosives were less safe when tested in the presence of coal dust alone. The results obtained at the German stations were not always confirmed by the other stations where pure artificial or natural gas is used. This may be explained by the fact that the pit gases used at many of the stations are not of uniform composition and contain more or less inert gases.

There is sometimes a small percentage of carbon dioxide and other inert gases present in the pit gases used abroad, depending on the efficiency and condition of the scrubbers at the time the gases are drawn through. Assuming that the percentage of these inert gases is kept within low limits, there may be at times sufficient inert gases present to have a retardative effect on the ignition. Tests made at the Pittsburgh experiment station indicate that a gas and air mixture containing 8.1 per cent of methane and ethane, 14.2 per cent of carbon dioxide (CO_2), and 77.7 per cent of air is practically nonexplosive when ignition is attempted with an electric igniter containing 5 grains of black powder. It was also found that the ignition of gas mixtures containing 11.7 per cent carbon dioxide is materially retarded and, even when ignited, burned at a slow rate accompanied with little if any explosion. For this reason it would be fair to assume that a gas mixture containing a small percentage of carbon dioxide or other inert gases would be proportionately less sensitive than a pure gas mixture.

The results of tests of the four foreign explosives reported in Bulletin 15 indicated that the natural gas used at the Pittsburgh experiment station is more sensitive than the pit gas used abroad, and that it would be necessary to reduce the percentage of gas in order that the results might be comparable to those obtained abroad. It was evident that gas and air mixtures containing about 6 per cent of methane and ethane were equivalent to the 8 per cent mixtures used abroad, and further that all explosives would be excluded if untamped shots were fired in the presence of air mixtures containing 8 per cent of methane and ethane.

A conference of several of the leading coal operators was called at the Pittsburgh experiment station, and the consensus of opinion was that a low percentage gas mixture with coal dust suspended in the air would more nearly represent the dangerous conditions that might exist in a coal mine, and that one of the tests, at least, should be made under these conditions with unstemmed shots, using a charge of not less than 680 grams (1½ pounds).

STANDARDIZING APPARATUS AND METHODS.

The question of standardizing universal methods and apparatus for testing coal-mining explosives is still an open one. It is obvious that an interrelation of the work of all stations aiming to unify or standardize apparatus and methods of testing explosives would be beneficial to all concerned, and it is hoped that such will eventually be the outcome.

It would seem that the design in the construction of all testing apparatus could be established on a uniform basis. In fact, it is the tendency at present to adopt the cylindrical type of steel gallery and steel cannon having a bore of 55 millimeters in diameter. The unifying of test requirements does not offer a ready solution. In Belgium the mines are unusually fiery and all explosives are required to pass a severe gas test. In recent years explosives have been tested in the presence of coal dust, but the dust used has a relatively low percentage of volatile matter as compared with that used in the United States.

In France great stress is put on the requirements of the gaseous products of combustion of explosives. The nitroglycerin class of explosives is practically eliminated from use in French coal mines. When permissible explosives of this class are properly used in the coal mines of the United States in quantities less than 1½ pounds per shot, it has been found that the amount of poisonous gases produced is so small that it is of little, if any, consequence. This is especially true when the ventilation current is brought directly to the working face. A testing gallery has recently been installed in France for determining the permissibility of explosives, hence the classification of explosives by calculating the theoretical temperature of explosion will no doubt be discontinued.

In England stemmed charges only are used for determining the permissibility of explosives for use in coal mines. This requirement would not always meet the conditions of mining in the United States. Although it is a reprehensible practice, miners have been known to fire permissible explosives in a drill hole with little, if any, stemming. For this reason unstemmed shots are one of the requirements of the Bureau of Mines for determining the permissibility of an explosive. It is understood that the new English testing station which is now in course of construction will test explosives without stemming in the presence of inflammable gas mixtures.

Six foreign coal-mining explosives were procured for comparative tests. The method of conducting the tests was approximately the same as that employed at the foreign testing stations.

The results of tests indicate that all of the foreign explosives, except explosive H, which detonated incompletely, would pass the Woolwich tests, but that all would fail to pass the Belgian tests. Only two of the explosives, namely, I and J, would pass the test requirements requisite for their being placed on the United States permissible list. In the gas and dust gallery tests explosive E failed in test 4; explosive F was not tested, as it failed to detonate completely in Belgian test; explosive G failed in test 4; and explosive H failed in test 1. Two of these explosives, namely, E and F, also failed in friction test.

The foreign explosives, namely, E, G, I, and J, were subjected to a suspended test, which simulates to some extent the procedure followed at one of the foreign testing stations. The test was made by suspending in the gallery 454 grams (1 pound) of the explosive, including the original wrapper. The charge was detonated in a mixture of gas and air containing 4 per cent of gas (methane and ethane) and 20 pounds of bituminous coal dust, 18 pounds of which was placed on shelves along the sides of the first 20 feet of the gallery, and 2 pounds placed so that it was stirred up by an air current in such a manner that all or a part of it would be suspended in the first division of the gallery. The explosive I was the only explosive that passed this test. The explosives G and J ignited the mixture in the first trial and explosive E ignited the mixture once out of two trials.

For convenience in reporting the results of tests. the six foreign explosives are here designated explosives E, F, G, H, I, and J.

Explosive E.
Class, potassium chlorate.
Physical examination:
  Diameter of cartridge, 4.45 centimeters (1¾ inches).
  Length of cartridge, 12.7 centimeters (5 inches).
  Average weight, 249 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 1.28.
  Color of explosive, yellow.
  Consistency, powdered, very fine, dry, soft, slightly cohesive.

Explosive F.
Class, potassium chlorate.
Physical examination:
  Diameter of cartridge, 4.45 centimeters (1¾ inches).
  Length of cartridge, 14.6 centimeters (5¾ inches).
  Average weight, 233 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 1.04.
  Color of explosive, corn.
  Consistency, powdered, very fine, dry, soft, not cohesive.

Explosive G.
Class, ammonium nitrate, containing nitroglycerin.
Physical examination:
  Diameter of cartridge, 4.45 centimeters (1¾ inches).
  Length of cartridge, 17.1 centimeters (6¾ inches).
  Average weight, 237 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 0.93.
  Color of explosive, corn.
  Consistency, granular and fibrous, fine, dry, soft, slightly cohesive.

Explosive H.
Class, ammonium nitrate.
Physical examination:
  Diameter of cartridge, 4.45 centimeters (1¾ inches).
  Length of cartridge, 15.5 centimeters (6⅛ inches).
  Average weight, 242 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 1.03.
  Color of explosive, corn.
  Consistency, granular, fine, dry, hard, slightly cohesive.

Explosive I.
Class, ammonium nitrate.
Physical examination:
  Diameter of cartridge, 4.45 centimeters (1¾ inches).
  Length of cartridge, 18.4 centimeters (7¼ inches).
  Average weight, 250 grams.
  Cartridge had been redipped.
  Apparent specific gravity of cartridge by sand, 0.86.
  Color of explosive, corn.
  Consistency, powdered, fine, dry, soft, not cohesive.

Explosive J.
Class, ammonium nitrate.
Physical examination:

- Diameter of cartridge, 4.45 centimeters (1¾ inches).
- Length of cartridge, 15.2 centimeters (6 inches).
- Average weight, 226 grams.
- Cartridge had been redipped.
- Apparent specific gravity of cartridge by sand, 0.94.
- Color of explosive, corn.
- Consistency, powdered, fine, dry, soft, not cohesive.

Chemical Analyses.

Chemical analyses of these six samples resulted as follows:

EXPLOSIVE E.

[Analyst, A. L. Hyde.]

Moisture	0.17
Dinitrotoluene	17.85
Mononitronaphthalene	1.30
Castor oil	5.32
Potassium chlorate	75.36
	100.00

Ash, 0.04.

EXPLOSIVE F.

Moisture	0.10
Nitrated rosin	24.63
Potassium chlorate	75.27
	100.00

Ash, 0.03.

EXPLOSIVE G.

Moisture	0.52
Nitroglycerin	8.13
Nitrotoluene	3.57
Castor oil	.81
Nitrocellulose	.56
Ammonium nitrate	82.11
Wood pulp	4.30
	100.00

Ash, 0.04.

EXPLOSIVE H.

Moisture	0.18
Ammonium nitrate	88.17
Trinitrotoluene	8.13
Mononitronaphthalene	3.52
	100.00

Ash, 0.07.

EXPLOSIVE I.

[Analyst, C. G. Storm.]

Moisture	0.06
Rosin	5.01
Ammonium nitrate	91.43
Potassium nitrate	3.50
	100.00

Ash, 0.08.

EXPLOSIVE J.

Moisture	0.45
Trinitrotoluene	4.82
Ammonium nitrate	90.50
Flour	4.23
	100.00

Ash, 0.07.

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF EACH EXPLOSIVE.

[Analyst, A. L. Hyde..]

Explosive.	Date (1912).	Test No.	Grams of original wrapper.	Products of combustion.		
				Gaseous.	Solid.	Liquid (water).
				Grams.	*Grams.*	*Grams.*
E	June 24	P 877	10	96.8	90.2	10.5
F	June 25	P 878	6	92.5	94.2	7.2
G	July 1	P 882	13	121.5	.0	70.0
H	July 2	P 883	10	120.8	1.2	71.0
I	July 3	P 884	10	110.5	3.1	80.5
J	July 6	P 886	8	106.2	2.1	81.0

GASEOUS PRODUCTS OF COMBUSTION, PERCENTAGE BY VOLUME.

Explosive.	Date (1912).	Test No.	H_2S.	CO_2.	CO.	O_2.	H_2.	CH_4.	N_2.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
E	June 24	P 877	0.0	34.1	41.5	0.0	15.6	0.5	8.3
F	June 25	P 878	.0	23.4	47.4	.0	23.9	.6	4.7
G	July 1	P 882	.0	28.7	5.9	.0	11.0	.8	53.6
H	July 2	P 883	.0	27.4	5.5	.0	9.1	.7	57.3
I	July 3	P 884	.0	25.5	3.0	.0	9.6	1.1	60.8
J	July 6	P 886	.0	30.0	.0	.1	.0	.2	69.7

SOLID PRODUCTS OF COMBUSTION, PERCENTAGE BY WEIGHT.

Explosive.	Date (1912).	Test No.	Products of combustion.	
			Soluble.	Insoluble.
			Per cent.	*Per cent.*
E	June 24	P 877	90.43	9.57
F	June 25	P 878	89.60	10.40

LARGE CALORIES DEVELOPED BY 1 KILOGRAM OF THE EXPLOSIVE.

Explosive.	Date (1912).	Charge.[a]	Test No.	Weight of water.	Rise in temperature.	Heat developed per kilogram.	Average heat developed per kilogram.
		Grams.		*Kilograms*	*°C.*	*Calories.*	*Calories.*
E	July 10	105	C 580	81.95	1.234	1,090.7	1,065.1
	11	105	C 581	81.95	1.176	1,039.0	
	11	105	C 582	81.95	1.206	1,065.7	
F	13	103	C 585	81.95	.966	868.5	865.5
	13	103	C 586	81.95	.957	860.4	
	15	103	C 587	81.95	.965	867.7	
G	15	106.5	C 588	81.95	1.300	1,133.2	1,169.2
	16	106.5	C 591	81.95	1.363	1,188.5	
	17	106.5	C 592	81.95	1.360	1,185.9	
H	17	105.0	C 593	([b])	([b])	([b])	....
	17	105.0	C 594	([b])	([b])	([b])	
I	17	105.0	C 595	81.95	1.371	1,212.7	1,218.6
	18	105.0	C 596	81.95	1.408	1,245.6	
	18	105.0	C 597	81.95	1.354	1,197.5	
J	19	104.0	C 598	81.95	1.439	1,285.5	....
	19	104.0	C 599	[c] 81.95	1.221	1,089.4	
	19	104.0	C 600	[c] 81.95	1.240	1,106.5	

[a] Charge consists of 100 grams of the explosive ingredient plus the proportionate amount of the original wrapper.

[b] Owing to erratic results obtained, results of tests not reported, incomplete detonation, nitrogen oxides evolved.

[c] Incomplete detonation—nitrogen oxides evolved.

COMPRESSION OF SMALL LEAD BLOCKS.

Charge, 100 grams.

Explosive.	Date (1912).	Test No.	Height before explosion.	Height after explosion.	Compression.
			Millimeters.	*Millimeters.*	*Millimeters.*
E	June 18	B 855	63.50	45.50	18.00
	18	B 856	63.25	45.25	18.00
	18	B 857	63.25	45.00	18.25
F	18	B 858	63.25	43.75	19.50
	18	B 859	63.50	44.25	19.25
	18	B 860	63.25	44.00	19.25
G	18	B 862	63.50	44.00	19.50
	18	B 863	63.25	44.50	18.75
	18	B 864	63.25	44.00	19.25
H	18	B 865	63.25	46.75	16.50
	18	B 868	63.25	46.00	17.25
	18	B 869	63.25	46.00	17.25
I	18	B 870	63.25	44.25	19.00
	18	B 871	63.25	44.00	19.25
	18	B 872	63.50	44.25	19.25
J	18	B 873	63.25	44.00	19.25
	18	B 874	63.25	44.00	19.25
	18	B 875	63.25	43.50	19.75

The average compression is as follows:

Explosive E, 18.1 millimeters (0.71 inch).
Explosive F, 19.3 millimeters (0.76 inch).
Explosive G, 19.2 millimeters (0.76 inch).
Explosive H, 17.0 millimeters (0.67 inch).
Explosive I, 19.2 millimeters (0.76 inch).
Explosive J, 19.4 millimeters (0.76 inch).

EXPANSION OF BORE HOLE OF TRAUZL LEAD BLOCKS.

Charge, 10 grams.

Explosive.	Date (1912).	Test No.	Volume of bore hole before shot.	Volume of bore hole after shot.	Expansion of bore hole.
			Cubic centimeters.	*Cubic centimeters.*	*Cubic centimeters.*
E	July 20	A 887	62	278	216
	20	A 888	62	268	206
	20	A 889	62	277	215
F	20	A 892	62	260	198
	Aug. 1	A 893	62	261	199
	1	A 894	62	269	207
G	July 20	A 881	62	357	295
	20	A 882	62	362	300
	20	A 883	62	353	291
H	June 15	A 873	62	329	267
	15	A 874	62	338	276
	15	A 875	62	343	281
I	15	A 877	62	288	226
	15	A 878	62	296	234
	15	A 876	62	274	[a] 212
J	July 20	A 884	62	303	241
	20	A 885	62	303	241
	20	A 886	62	315	253

[a] In this and other tests explosive detonated incompletely.

The average expansions follow:

Explosive E, 212 cubic centimeters (12.93 cubic inches).
Explosive F, 201 cubic centimeters (12.26 cubic inches).
Explosive G, 295 cubic centimeters (18.00 cubic inches).
Explosive H, 275 cubic centimeters (16.78 cubic inches).
Explosive J, 245 cubic centimeters (14.94 cubic inches).

UNIT DEFLECTIVE CHARGE AS DETERMINED BY THE BALLISTIC PENDULUM.

Explosive.	Date (1912).	Charge.	Swing.	Average swing.	Unit deflective charge.
		Grams.	*Inches.*	*Inches.*	*Grams.*
Pittsburgh experiment station 40 per cent standard dynamite	June 18	227	3.37	3.32	227
	18	227	3.30		
	18	227	3.28		
E	18	240	3.47	3.44	232
	18	240	3.43		
	18	240	3.41		
F	18	250	3.38	3.36	247
	18	250	3.38		
	18	250	3.33		
Pittsburgh experiment station 40 per cent standard dynamite	17	227	3.38	3.35	227
	17	227	3.31		
	17	227	3.35		
G	17	200	3.32	3.29	204
	17	200	3.27		
	17	200	3.28		
H	17	210	3.29	3.32	212
	17	210	3.35		
	17	210	3.31		
I	17	225	3.32	3.37	224
	17	225	3.38		
	17	225	3.42		
J	17	230	3.21	3.20	241
	17	230	3.16		
	17	230	3.23		

In order to test the foreign explosives at the Pittsburgh experiment station under conditions simulating the procedure followed at Woolwich, England, it was necessary to determine the standard Woolwich charge of each explosive. This was computed from the results of ballistic pendulum tests of the four foreign explosives reported in Bulletin 15, Chapter VIII. It was found that the Woolwich disruptive charge for an explosive was 69 per cent of that used at the Pittsburgh experiment station. The following tabulation gives the unit deflective charge and the Woolwich disruptive charge of the four foreign explosives as determined at the Pittsburgh experiment station:

Explosive.	Pittsburgh experiment station unit deflective charge.	Woolwich disruptive charge.	Percentage Woolwich charge compared with charge used at the Pittsburgh experiment station.
	Grams.	*Grams.*	
A	420	295	70
B	205	144	70
C	202	137	68
D	298	199	67
Average			69

Therefore, the Woolwich disruptive charge is 69 per cent of the charge used at the Pittsburgh experiment station, and this factor (0.69) was used in computing the standard Woolwich charge of the six foreign explosives reported herein.

In all tests in gas and dust gallery No. 1 the following electric detonators were used:

Explosive E, electric detonator No. 6.
Explosive F, electric detonator No. 6.
Explosive G, electric detonator No. 6.
Explosive H, electric detonator No. 7.
Explosive I, electric detonator No. 7.
Explosive J, electric detonator No. 7.

THE BELGIAN TEST (MODIFIED) FOR DETERMINATION OF THE LIMIT CHARGE IN A MIXTURE OF GAS AND AIR CONTAINING 8 PER CENT OF METHANE AND ETHANE.

Limit charge is established if five shots fail to ignite the mixture.

Explosive.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
		Grams.	*Per cent.*	
E	June 27	50	7.99	No ignition.
	27	50	8.17	Do.
	28	50	8.09	Do.
	28	50	7.94	Do.
	28	50	7.66	Ignition.
F	27	100	7.91	No ignition.[a]
	27	100	8.06	Do.[a]
	27	250	8.50	Do.[a]
G	July 1	50	8.03	Ignition.
H	June 28	50	7.78	No ignition.
	28	50	7.55	Ignition.
I	29	50	8.02	Do.
J	26	50	8.23	Do.

[a] Detonation incomplete.

The limit charges for this test are established as follows:

	Grams.
Explosive E	0
Explosive G	0
Explosive H	0
Explosive I	0
Explosive J	0

WOOLWICH TEST (MODIFIED).

Five shots with the standard (Woolwich) charge, in its original wrapper, shall be fired with 12 inches of clay stemming (tamped by hand) at a gallery temperature of 77° F. into a mixture of gas and air containing 8 per cent of methane and ethane. An explosive passes this test if all five shots fail to ignite the mixture.

Explosive.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
		Grams.	*Per cent.*	
E	Aug. 21	160	8.06	No ignition.
	21	160	8.05	Do.
	21	160	7.82	Do.
	21	160	8.46	Do.
	21	160	7.92	Do.
F	21	170	8.11	Do.
	21	170	7.90	Do.
	21	170	7.88	Do.
	21	170	7.88	Do.
	21	170	8.24	Do.
G	22	141	8.54	Do.
	23	141	8.40	Do.
	23	141	8.25	Do.
	23	141	8.07	Do.
	23	141	7.78	Do.
H	21	146	8.11	Do.[a]
	22	146	8.25	Do.[a]
	22	146	7.82	Do.[a]
I	22	155	8.00	Do.
	22	155	8.25	Do.
	22	155	8.11	Do.
	22	155	8.39	Do.
	22	155	8.05	Do.
J	22	166	8.31	Do.
	22	166	7.82	Do.
	22	166	7.93	Do.
	23	166	8.01	Do.
	23	166	7.98	Do.

[a] Detonation incomplete.

Explosives E, F, G, I, and J passed this test.

WOOLWICH TEST (MODIFIED).

Five shots with three-quarters of the standard (Woolwich) charge, in its original wrapper, shall be fired with 9 inches of clay stemming (tamped by hand) at a gallery temperature of 77° F. into a mixture of gas and air containing 8 per cent of methane and ethane. An explosive passes this test if all five shots fail to ignite the mixture.

Explosive.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
		Grams.	*Per cent.*	
E	Aug. 26	120	8.25	No ignition.
	26	120	7.93	Do.
	26	120	7.99	Do.
	26	120	7.83	Do.
	26	120	8.11	Do.
F	24	128	7.84	Do.
	24	128	7.77	Do.
	24	128	8.01	Do.
	24	128	8.03	Do.
	24	128	8.23	Do.
G	23	106	7.79	Do.
	23	106	7.96	Do.
	24	106	8.38	Do.
	24	106	7.82	Do.
	24	106	7.90	Do.
H (this test was not made on this explosive, as it failed to detonate completely in previous test with 12 inches of stemming).				
I	26	116	7.75	Do.
	26	116	8.50	Do.
	26	116	8.20	Do.
	26	116	8.44	Do.
	26	116	8.04	Do.
J	23	124	7.83	Do.
	23	124	7.79	Do.
	23	124	8.11	Do.
	23	124	7.79	Do.
	23	124	7.80	Do.

Explosives E, F, G, I, and J passed this test.

BUREAU OF MINES TESTS.

GAS AND DUST GALLERY NO. 1.

Test 1.

Explosive.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
		Grams.	*Per cent.*	
E	June 19	232	8.39	No ignition.
	19	232	8.23	Do.
	19	232	8.30	Do.
	19	232	8.29	Do.
	19	232	8.27	Do.
	19	232	8.31	Do.
	19	232	8.06	Do.
	20	232	7.91	Do.
	20	232	7.94	Do.
	20	232	8.33	Do.
F	20	247	7.88	Do.
	20	247	7.94	Do.
	20	247	8.30	Do.
	20	247	8.43	Do.
	20	247	8.33	Do.
	20	247	8.30	Do.
	20	247	7.87	Do.
	20	247	8.29	Do.
	20	247	8.45	Do.
	20	247	7.99	Do.
G	24	204	8.40	Do.
	24	204	8.14	Do.
	24	204	8.15	Do.
	24	204	8.12	Do.
	24	204	8.19	Do.
	24	204	8.39	Do.
	24	204	8.12	Do.
	24	204	8.08	Do.
	24	204	7.90	Do.
	24	204	8.33	Do.
H	24	212	7.92	Do.
	24	212	8.14	Do.
	25	212	8.07	Ignition.
I	21	224	8.01	No ignition.
	21	224	8.12	Do.
	22	224	8.36	Do.
	22	224	8.16	Do.
	22	224	8.04	Do.
	22	224	8.31	Do.
	22	224	8.06	Do.
	22	224	8.30	Do.
	22	224	7.98	Do.
	22	224	8.28	Do.
J	20	241	8.02	Do.
	21	241	8.06	Do.
	21	241	8.05	Do.
	21	241	8.20	Do.
	21	241	7.90	Do.
	21	241	8.26	Do.
	21	241	8.36	Do.
	21	241	8.06	Do.
	21	241	8.01	Do.
	21	241	8.34	Do.

Explosives E, F, G, I, and J passed this test.
Explosive H failed to pass this test.

GAS AND DUST GALLERY NO. 1.

Test 3.

Explosive.	Date (1912).	Weight of charge.	Result.
		Grams.	
E	Aug. 16	232	No ignition.
	16	232	Do.
	16	232	Do.
	16	232	Do.
	16	232	Do.
	16	232	Do.
	16	232	Do.
	16	232	Do.
	16	232	Do.
	16	232	Do.
F	20	247	Do.
	20	247	Do.
	20	247	Do.
	20	247	Do.
	20	247	Do.
	20	247	Do.
	20	247	Do.
	20	247	Do.
	20	247	Do.
	20	247	Do.
G	16	204	Do.
	16	204	Do.
	16	204	Do.
	16	204	Do.
	16	204	Do.
	17	204	Do.
	17	204	Do.
	17	204	Do.
	17	204	Do.
	17	204	Do.
H	20	212	Do.
	20	212	Do.
	20	212	Do.
	20	212	Do.
	20	212	Do.
	20	212	Do.
	20	212	Do.
	20	212	Do.
	20	212	Do.
	20	212	Do.
I	17	224	Do.
	17	224	Do.
	17	224	Do.
	17	224	Do.
	17	224	Do.
	19	224	Do.
	19	224	Do.
	19	224	Do.
	19	224	Do.
	19	224	Do.
J	19	241	Do.
	19	241	Do.
	19	241	Do.
	19	241	Do.
	19	241	Do.
	19	241	Do.
	19	241	Do.
	19	241	Do.
	20	241	Do.
	20	241	Do.

Explosives E, F, G, H, I, and J passed this test.

Gas and Dust Gallery No. 1.

Test 4.

Explosive.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
		Grams.	*Per cent.*	
E	Aug. 8	500	4.13	Ignition.
	8	350	4.18	No ignition.
	8	400	4.12	Do.
	9	450	4.13	Do.
	9	450	4.10	Ignition.
	9	400	3.92	No ignition.
	9	400	4.13	Ignition.
	9	350	4.25	Do.
	9	300	4.21	No ignition.
	9	300	4.15	Do.
	9	300	4.17	Do.
	9	300	4.19	Do.
	9	300	4.14	Do.
F (this test was not run on this explosive, as it failed to detonate completely in previous test when stemming was not used).				
G	2	100	3.89	Do.
	2	150	3.96	Do.
	3	200	4.42	Do.
	3	250	3.83	Do.
	3	350	3.92	Do.
	3	450	3.85	Ignition.
	3	400	4.15	No ignition.
	3	400	4.00	Ignition.
	5	200	4.14	No ignition.
	5	350	4.08	Do.
	5	350	4.10	Do.
	5	350	4.04	Ignition.
	5	300	4.03	No ignition.
	6	300	4.10	Do.
	6	300	4.23	Do.
	6	300	4.20	Do.
	9	300	4.16	Do.
H (this test not run, as explosive failed in Test 1).				
I	14	900	4.34	Do.
	14	1,000	4.25	Do.
J	8	350	4.03	Do.
	8	450	4.20	Do.
	8	600	4.22	Do.
	8	700	4.26	Do.
	8	800	4.05	Do.
	10	900	4.08	Do.
	10	1,000	4.21	Do.

For this test the following limit charges were established:

	Grams.
Explosive E	300
Explosive G	300
Explosive I (the capacity of the cannon)	1,000
Explosive J (the capacity of the cannon)	1,000

The following limit charges were established when the explosives were loaded air spaced. The diameter of the bore of the cannon was 2¼ inches (57 mm.) and the explosives were packed in cartridges having a diameter of 1¾ inches (45 mm.), except for explosive I, which was packed in a 2-inch (51-mm.) cartridge.

	Grams.
Explosive E	250
Explosive G	50
Explosive I	800
Explosive J	300

RATE OF DETONATION.

Diameter of cartridge, 1¼ inches.[a]
Electric detonator, No. 7.

Explosive.	Date (1912).	Distance between spark points.	Peripheral speed of drum per second.	Rate of detonation per second.
		Millimeters.	*Meters.*	*Meters.*
E[b]	June 27	15.70	43.5	2,771
F[b]	27	16.35	44.5	2,722
G	24	11.35	44.5	3,921
	25	11.60	45.0	3,879
	25	11.20	45.0	4,018
H	26	10.80	45.0	4,167
	26	10.30	45.0	4,369
	26	10.35	45.0	4,348
I	21	10.60	45.0	4,245
	21	10.70	45.0	4,206
	21	10.70	45.0	4,206
J	25	11.15	44.5	3,991
	26	11.50	45.0	3,913
	26	11.10	44.5	4,009

[a] The explosives H and I failed to detonate completely in 1¼-inch cartridges, therefore 1¾-inch cartridges were used.

[b] Explosive placed in iron pipe 1½ inches inside diameter and 42 inches long and closed at both ends by means of iron plugs.

The average rates of detonation of the explosives are as follows:

Explosive G, 3,939 meters per second (12,920 feet per second).
Explosive H, 4,295 meters per second (14,090 feet per second).
Explosive I, 4,219 meters per second (13,840 feet per second).
Explosive J, 3,971 meters per second (13,020 feet per second).

FLAME TEST.

Peripheral speed of film, 20 meters per second.

Explosive.	Date (1912).	Height of photograph.	Height of flame.	Duration distance.	Duration of flame.
		Millimeters.	*Inches.*	*Millimeters.*	*Milliseconds.*
E	July 2	9.75	12.32	7.00	0.350
	2	6.75	8.53	2.25	.112
	2	7.25	9.16	2.50	.125
F	2	10.00	12.63	7.25	.362
	2	9.75	12.32	5.75	.288
	2	9.50	12.00	5.50	.275
G	3	9.00	11.37	6.50	.325
	3	7.50	9.47	5.25	.262
	3	7.50	9.47	5.00	.250
H	3	(a)	(a)	(a)	(a)
I	5	7.75	9.79	2.25	.112
	5	7.00	8.84	2.50	.125
	9	7.25	9.16	1.75	.088
J	5	6.75	8.53	5.00	.250
	5	7.00	8.84	5.75	.288
	5	7.25	9.16	6.00	.300

(a) Incomplete detonation.

The average heights and durations of flame are as follows:

Explosive E, height 10.00 inches; duration, 0.196 millisecond.
Explosive F, height 12.32 inches; duration 0.308 millisecond.
Explosive G, height 10.10 inches; duration 0.279 millisecond.
Explosive I, height 9.26 inches; duration 0.108 millisecond.
Explosive J, height 8.84 inches; duration 0.279 millisecond.

SMALL IMPACT TEST.

Explosive.	Date (1912).	Distance of fall.	Number of trials.	Result.
		Centimeters.		
E	June 21	30	1	Explosion.
	21	10	1	No explosion.
	21	20	1	Do.
	21	25	1	Explosion.
	21	24	1	Do.
	21	23	5	No explosion.
F	21	25	1	Explosion.
	21	20	1	Do.
	21	10	1	Do.
	21	8	1	Do.
	21	6	1	Do.
	21	5	2	No explosion.
	21	5	1	Explosion.
	21	4	1	No explosion.
	21	4	1	Explosion.
	21	3	5	No explosion.
G	July 8	40	1	Explosion.
	8	36	1	No explosion.
	8	38	1	Do.
	8	39	5	Do.
H	9	60	1	Explosion.
	9	56	1	No explosion.
	9	58	1	Explosion.
	9	57	5	No explosion.
I	June 28	40	1	Do.
	28	60	1	Do.
	28	80	1	Do.
	28	100	1	Explosion.
	28	96	1	No explosion.
	28	98	1	Do.
	28	99	1	Explosion.
	28	98	1	Do.
	28	97	1	Do.
	July 8	96	1	Do.
	8	90	1	No explosion.
	8	93	1	Do.
	8	95	1	Explosion.
	8	94	1	Do.
	8	93	1	Do.
	8	92	1	Do.
	8	91	1	No explosion.
	8	91	1	Explosion.
	8	90	1	No explosion.
	8	90	1	Explosion.
	8	89	1	No explosion.
	8	89	1	Explosion.
	8	88	1	Do.
	8	87	1	No explosion.
	8	87	1	Explosion.
	8	86	1	Do.
	8	85	1	Do.
	8	84	2	No explosion.
	8	84	1	Explosion.
	8	83	1	Do.
	8	82	1	Do.
	8	81	1	Do.
	8	80	2	No explosion.
	8	80	1	Explosion.
	8	79	1	No explosion.
	8	79	1	Explosion.
	8	78	1	Do.
	8	77	1	No explosion.
	8	77	1	Explosion.
	8	76	5	No explosion.
J	9	60	1	Do.
	9	80	1	Do.
	9	100	5	Do.

The maximum heights that will cause no explosion established as follows:

Explosive E, 23 centimeters (9.06 inches).
Explosive F, 3 centimeters (1.18 inches).
Explosive G, 39 centimeters (15.35 inches).
Explosive H, 57 centimeters (22.44 inches).
Explosive I, 76 centimeters (29.92 inches).
Explosive J, 100 centimeters (39.37 inches), capacity of machine.

LARGE IMPACT TEST.

Explosive.	Date (1912).	Distance of fall.	Number of trials.	Amount recovered.	Result.
		Centimeters.		*Grams.*	
E	July 1	150	1	....	Explosion.
	1	60	1	....	Do.
	1	20	1	18	Do.
	1	10	3	20	No explosion.
F	May 31	100	1	....	Explosion.
	31	30	1	2	Do.
	31	20	1	1	Do.
	31	10	3	20	No explosion.
G	June 8	100	1	10	Explosion.
	8	50	1	10	Do.
	8	20	1	20	No explosion.
	8	40	3	20	Do.
H	17	100	1	20	Do.
	17	200	1	9	Explosion.
	17	160	1	20	No explosion.
	17	180	1	10	Explosion.
	17	170	1	10	Do.
	17	160	2	20	No explosion.
I	18	500	1	....	Explosion.
	18	300	1	8	Do.
	18	200	1	9	Do.
	18	100	1	20	No explosion.
	18	120	1	12	Explosion.
	18	110	3	20	No explosion.
J	19	600	1	....	Explosion.
	19	400	1	8	Do.
	19	200	1	9	Do.
	19	160	1	20	No explosion.
	19	190	3	20	Do.

The maximum heights that will cause no explosion established as follows:

Explosive E, 10 centimeters (3.94 inches).
Explosive F, 10 centimeters (3.94 inches).
Explosive G, 40 centimeters (15.75 inches).
Explosive H, 160 centimeters (62.99 inches).
Explosive I, 110 centimeters (43.31 inches).
Explosive J, 190 centimeters (74.80 inches).

EXPLOSION-BY-INFLUENCE TEST.

Explosive.	Date (1912).	Weight of each cartridge.	Distance separating cartridges.	Result, upper cartridge.
		Grams.	*Inches.*	
E	Aug. 26	206	4	Did not explode.
	26	206	1	Exploded.
	26	206	3	Did not explode.
	27	206	2	Exploded
	27	206	3	Did not explode.
	27	206	3	Do.
F	27	167	....	Incomplete detonation.
G	27	150	3	Did not explode.
	28	150	1	Exploded.
	28	150	2	Do.
	28	150	3	Did not explode.
	28	150	3	Do.
H (this test not made, as explosive failed to detonate completely in flame test).				
I	29	138	3	Do.
	29	138	1	Exploded.
	29	138	2	Did not explode.
	29	138	2	Do.
	29	138	2	Do.
J	28	151	3	Do.
	28	151	1	Exploded.
	28	151	2	Did not explode.
	28	151	2	Exploded.
	28	151	3	Did not explode.
	28	151	3	Do.

The minimum distance at which no explosion occurs established as follows:

	Inches.
Explosive E	3
Explosive G	3
Explosive I	2
Explosive J	3

THEORETICAL MAXIMUM PRESSURE DEVELOPED IN OWN VOLUME, AS DETERMINED BY BICHEL PRESSURE GAGE.

Indicator spring, 0.32 millimeter=1 kilogram per square centimeter.

Explosive.	Date (1912).	Test No.	Charge.[a]	Specific gravity.	Height of curve.	Pressure per square centimeter.	Cooling surface.	Average pressure per square centimeter.
			Grams.		*Millimeters.*	*Kilograms.*		*Kilograms.*
E	July 8	P 887	210	1.28	26.00	81.25	A	79.95
	8	P 888	210	1.28	26.00	81.25	A	
	8	P 891	210	1.28	24.75	77.34	A	
	8	PP 1137	210	1.28	24.25	75.78	B	74.74
	8	PP 1139	210	1.28	23.50	73.44	B	
	9	PP 1141	210	1.28	24.00	75.00	B	
	9	PP 1142	210	1.28	23.50	73.44	C	72.66
	9	PP 1143	210	1.28	23.00	71.88	C	
	9	PP 1144	210	1.28	23.25	72.66	C	
F	10	P 892	206	1.04	23.00	71.88	A	71.88
	10	P 894	206	1.04	23.00	71.88	A	
	10	P 896	206	1.04	23.00	71.88	A	
	10	PP 1149	206	1.04	22.25	69.53	B	68.23
	10	PP 1151	206	1.04	21.75	67.97	B	
	10	PP 1152	206	1.04	21.50	67.19	B	
	9	PP 1146	206	1.04	21.00	65.62	C	64.06
	9	PP 1147	206	1.04	20.50	64.06	C	
	9	PP 1148	206	1.04	20.00	62.50	C	
G	11	P 897	213	.93	38.75	121.09	A	120.57
	11	P 898	213	.93	38.75	121.09	A	
	11	P 899	213	.93	38.25	119.53	A	
	11	PP 1153	213	.93	35.50	110.94	B	110.94
	11	PP 1154	213	.93	35.50	110.94	B	
	11	PP 1155	213	.93	35.50	110.94	B	
	11	PP 1156	213	.93	34.75	108.59	C	107.81
	11	PP 1157	213	.93	34.50	107.81	C	
	12	PP 1158	213	.93	34.25	107.03	C	
H	12	P 900	210	1.03	36.75	114.84	A	115.36
	13	P 902	210	1.03	37.00	115.62	A	
	13	P 903	210	1.03	37.00	115.62	A	
	12	PP 1162	210	1.03	34.50	107.81	B	108.07
	12	PP 1164	210	1.03	34.50	107.81	B	
	13	PP 1165	210	1.03	34.75	108.59	B	
	12	PP 1159	210	1.03	33.00	103.12	C	104.95
	12	PP 1160	210	1.03	33.50	104.69	C	
	12	PP 1161	210	1.03	34.25	107.03	C	
I	19	P 910	210	.86	37.50	117.19	A	116.67
	20	P 911	210	.86	38.00	118.75	A	
	20	P 912	210	.86	36.50	114.06	A	
	16	PP 1166	210	.86	32.75	102.34	B	103.12
	16	PP 1167	210	.86	32.75	102.34	B	
	16	PP 1168	210	.86	33.50	104.69	B	
	16	PP 1169	210	.86	32.25	100.78	C	100.00
	16	PP 1170	210	.86	31.25	97.66	C	
	16	PP 1171	210	.86	32.50	101.56	C	
J	18	P 907	208	.94	36.00	112.50	A	114.84
	18	P 908	208	.94	37.00	115.62	A	
	18	P 909	208	.94	37.25	116.41	A	
	17	PP 1175	208	.94	32.25	100.78	B	102.60
	17	PP 1176	208	.94	33.50	104.69	B	
	17	PP 1177	208	.94	32.75	102.34	B	
	17	PP 1172	208	.94	32.00	100.00	C	100.52
	17	PP 1173	208	.94	32.00	100.00	C	
	17	PP 1174	208	.94	32.50	101.56	C	

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[a] Charge consists of 200 grams of explosive ingredient plus the proportionate amount of the original wrapper.

Computations for the respective explosives, established as the result of the above tests, were as follows:

Explosive E: $P=1.911A+0.5B-1.411C=87.63$ kilograms per square centimeter. $V=15{,}000$ cubic centimeters. $S=1.28$. $W=210$ grams. $M=\frac{VPS}{W}=8{,}012$ kilograms per square centimeter (113,960 pounds per square inch).

Explosive F: $P=1.911A+0.5B-1.411C=81.09$ kilograms per square centimeter. $V=15,000$ cubic centimeters. $S=1.04$. $W=206$ grams. $M=\frac{VPS}{W}=6,141$ kilograms per square centimeter (87,340 pounds per square inch).

Explosive G: $P=1.911A+0.5B-1.411C=133.76$ kilograms per square centimeter. $V=15,000$ cubic centimeters. $S=0.93$. $W=213$ grams. $M=\frac{VPS}{W}=8,760$ kilograms per square centimeter (124,600 pounds per square inch).

Explosive H: $P=1.911A+0.5B-1.411C=126.40$ kilograms per square centimeter. $V=15,000$ cubic centimeters. $S=1.03$. $W=210$ grams. $M=\frac{VPS}{W}=9,299$ kilograms per square centimeter (132,260 pounds per square inch).

Explosive I: $P=1.911A+0.5B-1.411C=133.42$ kilograms per square centimeter. $V=15,000$ cubic centimeters. $S=0.86$. $W=210$ grams. $M=\frac{VPS}{W}=8,196$ kilograms per square centimeter (116,570 pounds per square inch).

Explosive J: $P=1.911A+0.5B-1.411C=128.93$ kilograms per square centimeter. $V=15,000$ cubic centimeters. $S=0.94$. $W=208$ grams. $M=\frac{VPS}{W}=8,740$ kilograms per square centimeter (124,310 pounds per square inch).

PENDULUM FRICTION TEST.

Explosive.	Date (1912).	Test No.	Charge on grooved steel plate.	Weights used.	Distance of fall.	Kind of shoe.	Result.
			Grams.	*Kilograms.*	*Meters.*		
E	Mar. 14	U 211	7	20	1½	Steel	Explosion in first of 10 trials (180 swings).
E	Apr. 4	U 222	7	20	1½	Fiber	No explosion or burning in 10 trials (180 swings), but local cracking in second and fourth trials.[a]
F	Mar. 14	U 212	7	20	1½	Steel	Explosion in fourth, fifth, seventh, and ninth of 10 trials (180 swings).
F	Apr. 4	U 223	7	20	1½	Fiber	Explosion in eighth of 10 trials (180 swings).
G	do	U 218	7	20	1½	Steel	No explosion or burning in 10 trials (180 swings), but local cracking in third and ninth trials.[a]
H	do	U 219	7	20	1½	Steel	No explosion or burning in 10 trials (180 swings), but local cracking in seventh trial.[a]
I	do	U 220	7	20	1½	Steel	No explosion or burning in 10 trials (180 swings), but local cracking in second, fifth, eighth, and ninth trials.[a]
J	do	U 221	7	20	1½	Steel	No explosion or burning in 10 trials (180 swings), but local cracking in first, fourth, seventh, and tenth trials.[a]

[a] Scarcely audible.

Explosives E and F failed to pass this test.

Friction tests were made with the six foreign explosives under conditions simulating those prevailing in England. Approximately 10 grams of each explosive was spread ⅛ inch thick on a wooden block and struck 10 glancing blows with a rawhide mallet. Sharp cracking occurred with explosives E and F but no audible cracking was noted when the other explosives were tested. It is worthy of note that in no instance did a complete explosion occur, but when tested with the pendulum friction machine explosives E and F detonated completely.

LIMIT CHARGE WITH VARIOUS GAS AND AIR MIXTURES.

The following tabulations show the limit charges established with the foreign explosives E, G, I, and J when fired in the presence of various gas and air mixtures. No stemming was used in any of the tests, but tests were made with different loading densities in the bore of the cannon.

Limit Charge Tests with Explosive E.

(Charging density of 1.)

Test in gas mixture containing 5 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 26	400	5.14	No ignition.	July 29	700	5.06	No ignition.
Do	400	5.11	Do.	Do	750	5.00	Ignition.
Do	500	5.13	Do.	July 30	700	4.97	No ignition.
Do	600	5.22	Do.	Do	700	5.01	Ignition.
Do	700	5.23	Do.	Do	600	4.94	No ignition.
Do	800	5.03	Do.	Aug. 1	650	5.22	Ignition.
July 27	900	5.11	Do.	Do	600	5.07	No ignition.
Do	1,000	5.04	Ignition.	Do	600	5.01	Do.
Do	900	5.16	Do.	Do	600	4.91	Do.
July 29	800	5.19	Do.				

Limit charge established at 600 grams for explosive E when fired with a charging density of 1 in the presence of a 5 per cent gas mixture.

Test in gas mixture containing 6 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 1	50	6.04	No ignition.	July 16	200	6.02	Ignition.
July 10	200	5.97	Do.	Do	150	6.00	No ignition.
Do	400	6.17	Ignition.	Do	150	6.06	Do.
July 12	200	5.95	No ignition.	July 17	150	6.28	Do.
July 13	250	6.18	Do.	Do	150	6.25	Do.
July 15	300	6.25	Do.	Do	150	6.14	Do.
July 16	350	5.93	Do.				

Limit charge established at 150 grams for explosive E when fired with a charging density of 1 in the presence of a 6 per cent gas mixture.

Test in gas mixture containing 7 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
June 28	100	6.99	Ignition.	July 2	50	7.21	No ignition.
July 1	50	6.94	No ignition.	Do	50	6.92	Do.
July 2	50	6.82	Do.	Do	50	6.97	Do.

Limit charge established at 50 grams for explosive E when fired with a charging density of 1 in the presence of a 7 per cent gas mixture.

Test in gas mixture containing 8 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
June 27	50	7.99	No ignition.	June 28	50	7.94	No ignition.
Do	50	8.17	Do.	Do	50	7.66	Ignition.
June 28	50	8.09	Do.				

Limit charge established at 0 gram for explosive E when fired with a charging density of 1 in the presence of an 8 per cent gas mixture.

Test in gas mixture containing 8½ per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
June 27	200	8.25	Ignition.	June 27	50	8.45	No ignition.
Do	150	8.37	Do.	Do	50	8.52	Do.
Do	100	8.85	Do.	June 28	50	7.66	Ignition.

Limit charge established at 0 gram for explosive E when fired with a charging density of 1 in the presence of an 8½ per cent gas mixture.

Test in gas mixture containing 9 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
June 27	50	8.80	No ignition.	July 18	50	8.99	Ignition.

Limit charge established at 0 gram for explosive E when fired with a charging density of 1 in the presence of a 9 per cent gas mixture.

Test in gas mixture containing 10 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 20	100	9.83	Ignition.	July 22	50	10.14	No ignition.
July 18	50	9.86	No ignition.	July 23	50	9.93	Do.
Do	50	10.09	Do.	Do	50	10.14	Do.

Limit charge established at 50 grams for explosive E when fired with a charging density of 1 in the presence of a 10 per cent gas mixture.

LIMIT CHARGE TESTS WITH EXPLOSIVE G.

(Charging density of 1.)

Test in gas mixture containing 5 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 24........	200	5.19	Ignition.	July 25........	50	5.23	No ignition.
Do........	100	4.89	Do.	Do........	50	4.84	Do.
July 25........	50	4.97	No ignition.	Do........	50	5.09	Do.
Do........	50	5.10	Do.				

Limit charge established at 50 grams for explosive G when fired with a charging density of 1 in the presence of a 5 per cent gas mixture.

On July 1, 1912, a 50-gram charge was fired into a gas mixture containing 6.23 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired with a charging density of 1 in the presence of a 6 per cent gas mixture.

Test in gas mixture containing 7 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 11........	50	6.87	No ignition.	July 11........	50	7.03	Ignition.
Do........	100	6.76	Ignition.				

Limit charge established at 0 gram for explosive G when fired with a charging density of 1 in the presence of a 7 per cent gas mixture.

On July 1, 1912, a 50-gram charge was fired into a gas mixture containing 8.03 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired with a charging density of 1 in the presence of an 8 per cent gas mixture.

Test in gas mixture containing 8½ per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
June 25.......	100	8.51	Ignition.	June 25	50	8.42	Ignition.

Limit charge established at 0 gram for explosive G when fired with a charging density of 1 in the presence of an 8½ per cent gas mixture.

On July 17, 1912, a 50-gram charge was fired into a gas mixture containing 9.17 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired with a charging density of 1 in the presence of a 9 per cent gas mixture.

On July 18, 1912, a 50-gram charge was fired into a gas mixture containing 10.16 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired with a charging density of 1 in the presence of a 10 per cent gas mixture.

LIMIT CHARGE TESTS WITH EXPLOSIVE I.

(Charging density of 1.)

Test in gas mixture containing 6 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 8	50	6.22	No ignition.	July 9	400	5.99	No ignition.
Do	100	5.95	Do.	Do	500	6.16	Do.
Do	150	6.30	Do.	Do	600	6.26	Do.
Do	150	6.28	Do.	Do	700	5.47	Do.
Do	200	5.99	Do.	July 23	800	5.75	Do.
July 9	250	6.29	Do.	July 24	900	6.04	Do.
Do	300	6.13	Do.	Do	1,000	6.06	Do.
Do	350	6.35	Do.				

Limit charge established at 1,000 grams (the capacity of the cannon) for explosive I when fired with a charging density of 1 in the presence of a 6 per cent gas mixture.

On July 3, 1912, a 50-gram charge was fired into a gas mixture containing 7.20 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired with a charging density of 1 in the presence of a 7 per cent gas mixture.

On June 29, 1912, a 50-gram charge was fired into a gas mixture containing 8.02 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired with a charging density of 1 in the presence of an 8 per cent gas mixture.

On June 25, 1912, a 50-gram charge was fired into a gas mixture containing 8.72 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired with a charging density of 1 in the presence of an 8½ per cent gas mixture.

On July 18, 1912, a 50-gram charge was fired into a gas mixture containing 8.80 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired with a charging density of 1 in the presence of a 9 per cent gas mixture.

Test in gas mixture containing 10 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 22	50	10.25	No ignition.[a]	July 23	50	9.86	No ignition.[a]
July 23	50	10.30	Do.[a]				

[a] Incomplete detonation; tests discontinued.

Limit charge established at 0 gram for explosive I when fired with a charging density of 1 in the presence of a 10 per cent gas mixture.

LIMIT CHARGE TESTS WITH EXPLOSIVE J.

(Charging density of 1.)

Test in gas mixture containing 5 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 26	200	4.85	No ignition.	July 27	700	5.17	No ignition.
Do	300	4.83	Do.	Do	900	5.20	Do.
Do	400	4.92	Do.	July 29	1,000	5.10	Do.
Do	500	5.04	Do.				

Limit charge established at 1,000 grams (the capacity of the cannon) for explosive J when fired with a charging density of 1 in the presence of a 5 per cent gas mixture.

On July 6, 1912, a 50-gram charge was fired into a gas mixture containing 6.24 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired with a charging density of 1 in the presence of a 6 per cent gas mixture.

Test in gas mixture containing 7 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 5	50	7.05	No ignition.	July 5	50	6.94	Ignition.
Do	100	7.09	Ignition.				

Limit charge established at 0 gram for explosive J when fired with a charging density of 1 in the presence of a 7 per cent gas mixture.

On June 26, 1912, a 50-gram charge was fired into a gas mixture containing 8.23 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired with a charging density of 1 in the presence of an 8 per cent gas mixture.

Test in gas mixture containing 9 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 17	50	9.21	No ignition.	July 17	50	8.80	Ignition.

Limit charge established at 0 gram for explosive J when fired with a charging density of 1 in the presence of a 9 per cent gas mixture.

On July 18, 1912, a 50-gram charge was fired into a gas mixture containing 9.97 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired with a charging density of 1 in the presence of a 10 per cent gas mixture.

Limit Charge Tests with Explosive E.

(Charge air spaced.)

Test in gas mixture containing 5 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 30	650	5.08	Ignition.	July 31	450	4.85	Ignition.
Do	600	4.89	Do.	Do	400	5.17	No ignition.
Do	550	4.89	Do.	Do	400	5.14	Do.
July 31	400	5.13	No ignition.	Do	400	5.12	Do.
Do	450	5.15	Do.	Do	400	5.03	Do.
Do	450	5.09	Do.				

Limit charge established at 400 grams for explosive E when fired air spaced in the presence of a 5 per cent mixture.

Test in gas mixture containing 6 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 10	400	6.04	Ingition.	July 12	250	5.92	Ignition.
Do	250	6.14	No ignition.	July 13	200	6.02	No ignition.
July 11	300	6.14	Do.	Do	200	6.23	Do.
Do	350	6.13	Do.	Do	200	6.09	Ignition.
Do	350	6.21	Do.	Do	150	6.14	No ignition.
July 12	350	6.11	Do.	Do	150	6.36	Do.
Do	350	6.08	Ignition.	July 15	150	6.22	Do.
Do	250	5.91	No ignition.	Do	150	6.27	Do.
Do	250	6.16	Do.	July 17	150	6.07	Do.
Do	300	6.09	Ignition.				

Limit charge established at 150 grams for explosive E when fired air spaced in the presence of a 6 per cent gas mixture.

Test in gas mixture containing 7 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 2	100	6.75	No ignition.	July 2	100	7.13	No ignition.
Do	100	6.83	Do.	Do	100	7.09	Do.
Do	150	6.68	Ignition.	Do	100	7.11	Do.

Limit charge established at 100 grams for explosive E when fired air spaced in the presence of a 7 per cent gas mixture.

On June 28, 1912, a 50-gram charge was fired into a gas mixture containing 8.10 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired air spaced in the presence of an 8 per cent gas mixture.

Test in gas mixture containing 9 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams*	*Per cent.*	
July 18	50	9.00	No ignition.	July 18	50	8.96	Ignition.

Limit charge established at 0 gram for explosive E when fired air spaced in the presence of a 9 per cent gas mixture.

Test in gas mixture containing 10 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 19	150	9.63	Ignition.	July 22	50	10.08	No ignition.
July 20	100	9.42	Do.	Do	50	10.19	Do.
Do	50	9.94	No ignition.	Do	50	10.03	Do.
July 22	100	10.22	Ignition.	Do	50	10.21	Do.

Limit charge established at 50 grams for explosive E when fired air spaced in the presence of a 10 per cent gas mixture.

LIMIT CHARGE TESTS WITH EXPLOSIVE G.

(Charge air spaced.)

Test in gas mixture containing 5 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 25	100	4.92	No ignition.	July 25	50	5.04	No ignition.
Do	150	4.85	Do.	Do	50	5.19	Do.
Do	200	5.10	Ignition.	Do	50	4.90	Do.
Do	150	5.28	Do.	Do	50	5.23	Do.
Do	100	5.00	No ignition.	Do	50	5.11	Do.
Do	100	5.14	Ignition.				

Limit charge established at 50 grams for explosive G when fired air spaced in the presence of a 5 per cent gas mixture.

On July 1, 1912, a 50-gram charge was fired into a gas mixture containing 6.00 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired air spaced in the presence of a 6 per cent gas mixture.

On July 11, 1912, a 50-gram charge was fired into a gas mixture containing 6.81 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired air spaced in the presence of a 7 per cent gas mixture.

On July 1, 1912, a 50-gram charge was fired into a gas mixture containing 7.54 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired air spaced in the presence of an 8 per cent gas mixture.

On June 25, 1912, a 50-gram charge was fired into a gas mixture containing 8.43 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired air spaced in the presence of an 8½ per cent gas mixture.

On July 17, 1912, a 50-gram charge was fired into a gas mixture containing 8.97 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired air spaced in the presence of a 9 per cent gas mixture.

On July 23, 1912, a 50-gram charge was fired into a gas mixture containing 9.99 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired air spaced in the presence of a 10 per cent gas mixture.

LIMIT CHARGE TESTS WITH EXPLOSIVE I.

(Charge air spaced.)

On July 30, 1912, a 1,000-gram charge was fired into a gas mixture containing 5.95 per cent methane and ethane. Result: No ignition. The limit charge was established at 1,000 grams (the capacity of the cannon) when fired air spaced in the presence of a 6 per cent gas mixture.

Test in gas mixture containing 7 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 3	50	6.81	No ignition.	July 5	150	7.00	No ignition.
Do	50	7.14	Do.	Do	150	7.05	Do.
Do	100	7.02	Do.	Do	150	7.23	Do.
Do	200	6.61	Ignition.	Do	150	7.04	Do.
Do	150	6.92	No ignition.				

Limit charge established at 150 grams for explosive I when fired air spaced in the presence of a 7 per cent gas mixture.

Test in gas mixture containing 8 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*	
July 1	50	7.83	No ignition.
Do	50	8.04	Ignition.

Limit charge established at 0 gram for explosive I when fired air spaced in the presence of an 8 per cent gas mixture.

On June 26, 1912, a 50-gram charge was fired into a gas mixture containing 8.58 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired air spaced in the presence of an 8½ per cent gas mixture.

On July 18, 1912, a 50-gram charge was fired into a gas mixture containing 8.93 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired air spaced in the presence of a 9 per cent gas mixture.

Test in gas mixture containing 10 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*	
July 22	150	9.91	Ignition.
July 23	50	10.00	Do.

Limit charge established at 0 gram for explosive I when fired air spaced in the presence of a 10 per cent gas mixture.

LIMIT CHARGE TESTS WITH EXPLOSIVE J.

(Charge air spaced.)

On July 30, 1912, a 1,000-gram charge was fired into a gas mixture containing 4.88 per cent methane and ethane. Result: No ignition. The limit charge was established at 1,000 grams (the capacity of the cannon) when fired air spaced in the presence of a 5 per cent gas mixture.

Test in gas mixture containing 6 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.	Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*			*Grams.*	*Per cent.*	
July 6	100	6.15	Ignition.	July 8	50	6.21	No ignition.
July 8	50	6.07	No ignition.	Do	50	6.31	Do.
Do	50	5.95	Do.	Do	50	6.14	Do.

Limit charge established at 50 grams for explosive J when fired air spaced in the presence of a 6 per cent gas mixture.

Test in gas mixture containing 7 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*	
July 6	100	6.81	Ignition.
Do	50	6.90	No ignition.
Do	50	6.79	Ignition.

Limit charge established at 0 gram for explosive J when fired air spaced in the presence of a 7 per cent gas mixture.

On August 26, 1912, a 50-gram charge was fired into a gas mixture containing 7.90 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired air spaced in the presence of an 8 per cent gas mixture.

On June 26, 1912, a 50-gram charge was fired into a gas mixture containing 8.55 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired air spaced in the presence of an 8½ per cent gas mixture.

On July 17, 1912, a 50-gram charge was fired into a gas mixture containing 9.01 per cent methane and ethane. Result: Ignition. The limit charge was established at 0 gram when fired air spaced in the presence of a 9 per cent gas mixture.

Test in gas mixture containing 10 per cent gas.

Date (1912).	Weight of charge.	Methane and ethane.	Result.
	Grams.	*Per cent.*	
July 18	50	9.72	Ignition.
July 23	50	10.55	Do.

Limit charge established at 0 gram for explosive J when fired air spaced in the presence of a 10 per cent gas mixture.

It is to be noted that the limit charge established with all of the foreign explosives tested in the presence of 8, 8½, and 9 per cent gas mixtures is 0 gram, even though the explosive was loaded with different charging densities (figs. 3, 4, 5, 6).

When these explosives were fired in the presence of 10 per cent gas the highest limit charge established was 50 grams (explosive E). The conditions of loading in the cannon were apparently not a factor in the limit charge established.

When the explosives were fired in the presence of 7 per cent gas the limit charge established was 0 gram for explosives G and J. The limit charge established for explosive I was 0 gram when loaded with a density of 1, and 150 grams when loaded air spaced. Explosive E also gave a higher limit charge when loaded air spaced than when loaded with a density of 1, namely, 100 and 50 grams, respectively.

When the explosives were fired in the presence of 6 per cent gas the limit charge established for explosive G was 0 gram, and 1,000 grams for explosive I, the results being the same irrespective of the charging

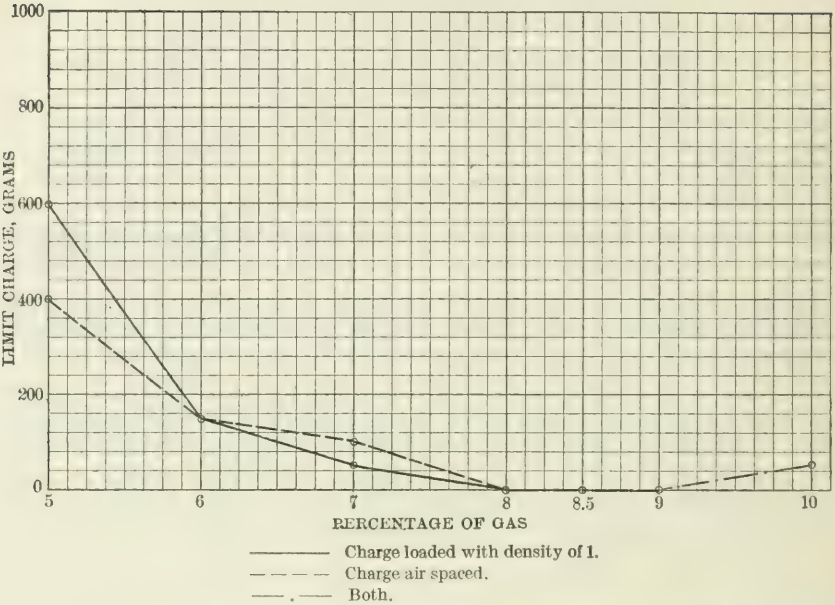

FIGURE 3.—Foreign explosive E. Limit charge established with various gas percentages. Composition of explosive: Moisture, 0.17; dinitrotoluene, 17.85; potassium chlorate, 75.36; castor oil, 5.32; mononitronaphthalene, 1.30; total 100.

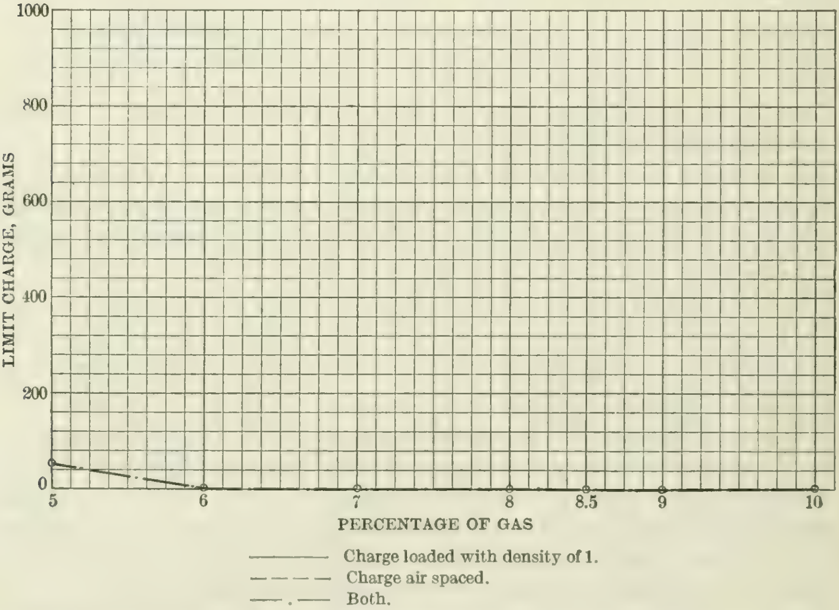

FIGURE 4.—Foreign explosive G. Limit charge established with various gas percentages. Composition of explosive: Moisture, 0.52; nitroglycerin, 8.13; ammonium nitrate, 82.11; nitrotoluene, 3.57; wood pulp, 4.30; castor oil, 0.81; nitrocellulose, 0.56; total, 100.

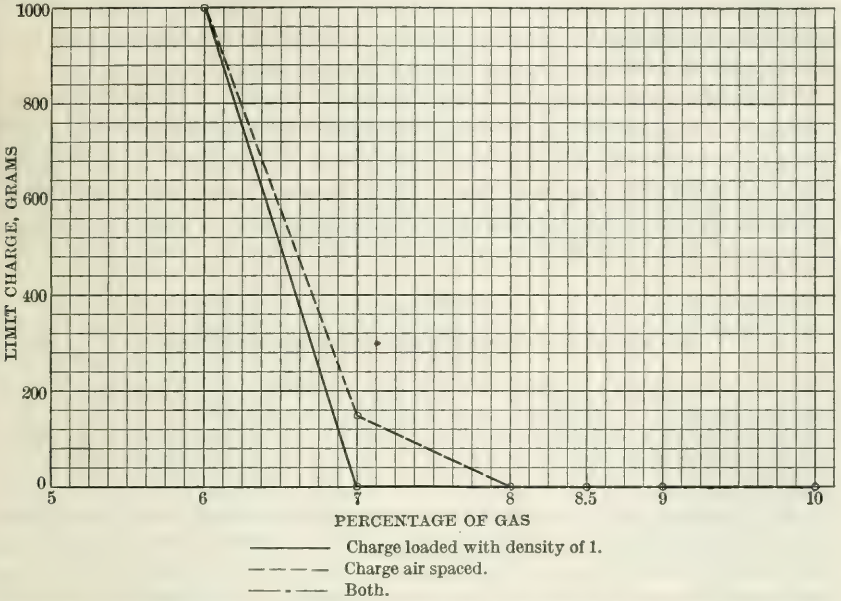

Figure 5.—Foreign explosive I. Limit charge established with various gas percentages. Composition of explosive: Moisture, 0.06; ammonium nitrate, 91.43; potassium nitrate, 3.50; rosin, 5.01; total, 100.

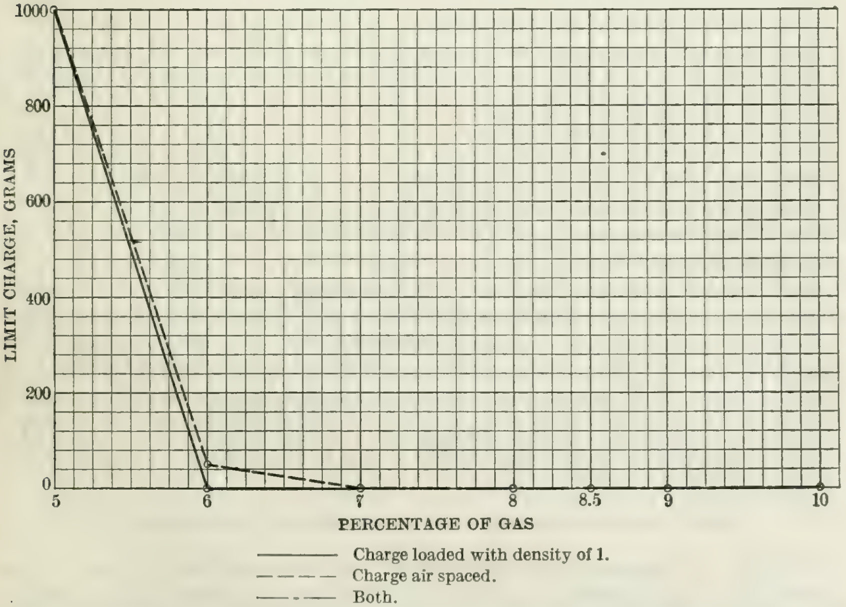

Figure 6.—Foreign explosive J. Limit charge established with various gas percentages. Composition of explosive: Moisture, 0.45; ammonium nitrate, 90.50; trinitrotoluene, 4.82; flour, 4.23; total, 100.

density. Explosive J gave a limit charge of 50 grams when air spaced, and 0 gram when loaded with a density of 1. The limit charge established for explosive E was 150 grams when loaded air spaced and also when loaded with a charging density of 1.

When the explosives were fired in the presence of 5 per cent gas, 50 grams was established as the limit charge for explosive G, and 1,000 grams for explosive J. The same results were obtained when loaded with different charging densities. Six hundred grams was established as the limit charge for explosive E when loaded with a density of 1, and 400 grams was established when loaded air spaced.

APPENDIX.

BUREAU OF MINES TESTS OF EXPLOSIVES.

CONDITIONS UNDER WHICH EXPLOSIVES ARE TESTED.

The conditions under which the Bureau of Mines tests explosives to determine whether they shall be placed on its list of permissible explosives are as follows:

1. The manufacturer is to deliver to the Bureau of Mines, Fortieth and Butler Streets, Pittsburgh, Pa., three weeks prior to the date set for tests, 100 pounds of each explosive that he desires to have tested. He is to be responsible for the care, handling, and delivery of this material to the experiment station, and he is to have a representative present during the tests if he so desires. In order to avoid duplication of work, it is requested that the smallest size of cartridge that the manufacturer intends to place on the market be sent for these tests.

2. The manufacturer will be required to pay fees for tests of explosives as outlined in Schedule 1[a] of the Bureau of Mines. This schedule may be procured from the Director of the Bureau of Mines, Washington, D. C.

3. No one is to be present at or participate in these tests except the necessary Government officers at the experiment station, their assistants, and the representative of the manufacturer of the explosives to be tested.

4. The tests will be made in the order of the receipt of the applications for them, provided the necessary quantity of the explosive is delivered at the testing station by the date set, of which date due notice will be given by the Bureau of Mines.

5. A list of the explosives that pass certain requirements satisfactorily will be furnished to State mine inspectors and will be made public in such other manner as may be considered desirable.

6. The details of results of tests are to be considered confidential by the manufacturer and are not to be made public prior to official publication by the Bureau of Mines.

7. From time to time field samples of permissible explosives will be collected, and tests will be made of these explosives as they are supplied for use in coal mines in the various States. Field samples when collected in original containers will not only be retested for their permissibility, but the analysis of each ingredient of the explosive must agree, within a reasonable variation, to the results obtained with the original sample submitted for tests.

TEST REQUIREMENTS FOR PERMISSIBLE EXPLOSIVES.

The tests will be made by the engineers of the Bureau of Mines in gas and dust gallery No. 1 at Pittsburgh, Pa., or in one of its identical galleries. The charge of explosive to be fired in tests 1 and 3 shall be equal in deflective power, as determined by the ballistic pendulum, to one-half pound (227 grams) of 40 per cent nitroglycerin dynamite in its original wrapper, of the following formula:

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[a] Fees for testing explosives and conditions and requirements under which explosives are tested. 1911. 6 pp.

	Per cent.
Nitroglycerin	40
Nitrate of soda (sodium nitrate)	44
Wood pulp	15
Carbonate of lime (calcium carbonate)	1
	100

Each charge shall be fired with an electric detonator (exploder or cap) which will completely detonate or explode the charge, as recommended by the manufacturer. The explosive must be in such condition that the chemical and physical tests do not show any unfavorable results.

An explosive will be considered unsatisfactory if it is not chemically stable, if it shows leakage of nitroglycerin, or if it is in such a condition that exudation of nitroglycerin will occur in handling or transportation.

A 680-gram (1½-pound) charge of an explosive must not evolve 158 liters (5½ cubic feet) or more of poisonous gases as determined by gage tests. The poisonous gases that are likely to be evolved on explosion are carbon monoxide, hydrogen sulphide, and nitrogen oxides.

Explosives that require a charge of more than 680 grams (1½ pounds) to satisfactorily break down coal under normal conditions of mining will be considered unsatisfactory. The size of the charge is determined by tests with the ballistic pendulum.

An explosive will be considered unsatisfactory if it is too sensitive to frictional impact (a glancing blow). Such sensitiveness is determined by the pendulum friction device when the shoe is faced with fiber.

In order that the dust used in tests 3 and 4 may be of the same quality, it is always taken from the same mine, ground to the same fineness, and used while still fresh.

The following are the gallery tests to which are subjected the explosives that the Bureau of Mines is asked to place in the list of permissible explosives:

Test 1. Ten shots each with the charge as described above, in its original wrapper, shall be fired, each tamped with 1 pound [a] of clay stemming, at a gallery temperature of 77° F., into a mixture of gas and air containing 8 per cent of gas (methane and ethane). An explosive is considered to have passed the test if no one of the 10 shots ignites this mixture.

Test 3. Ten shots each with the charge as described above, in its original wrapper, shall be fired, each tamped with 1 pound [a] of clay stemming, at a gallery temperature of 77° F., into 40 pounds of bituminous coal dust, 20 pounds of which is to be distributed uniformly on a wooden bench placed in front of the cannon and 20 pounds placed on side shelves in sections 4, 5, and 6. An explosive is considered to have passed the test if no one of the 10 shots ignites this mixture.

Test 4. Five shots each with 1½-pound charge, in its original wrapper, shall be fired without stemming, at a gallery temperature of 77°F., into a mixture of gas and air containing 4 per cent of gas (methane and ethane) and 20 pounds of bituminous coal dust, 18 pounds of which is to be placed on shelves along the sides of the first 20 feet of the gallery and 2 pounds to be so placed that it will be stirred up by an air current in such manner that all or part of it will be suspended in the first division of the gallery. An explosive is considered to have passed the test if no one of the five shots ignites this mixture.

DEFINITION OF PERMISSIBLE EXPLOSIVE.

An explosive is called a permissible explosive when it is similar in all respects to the sample that passed certain tests by the United States Bureau of Mines and when it is used in accordance with the conditions prescribed by this bureau.

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[a] Two pounds of clay stemming are used with slow-burning explosives.

Subject to the conditions and provisions stated above, the following explosives are classified as permissible explosives:

TABLE 1.—*Permissible explosives tested prior to Mar. 1, 1913.*

Brand.	Class designation.	When used with detonators, preferably electric detonators, of not less efficiency than—	Manufacturer.
Ætna coal powder A	Class 4	No. 6	Ætna Powder Co., Chicago, Ill.
Ætna coal powder AA	Class 1*a*	do	Do.
Ætna coal powder B	Class 4	do	Do.
Ætna coal powder C	do	do	Do.
Bental coal powder No. 1–A	Class 1*a*	do	Independent Powder Co., Joplin, Mo.
Bental coal powder No. 2	do	No. 7	Do.
Bituminite No. 1	Class 4	No. 6	Jefferson Powder Co., Birmingham, Ala.
Bituminite No. 3	do	do	Do.
Bituminite No. 4	do	do	Do.
Bituminite No. 5	Class 1*a*	do	Do.
Black Diamond No. 2–A	Class 4	do	Illinois Powder Manufacturing Co., St. Louis, Mo.
Black Diamond No. 3–A	do	do	Do.
Black Diamond No. 5	Class 1*a*	do	Do.
Cameron mine powder No. 1–A	do	do	Cameron Powder Manufacturing Co., Emporium, Pa.
Cameron mine powder No. 2–A	do	do	Do.
Cameron mine powder No. 2–A, L. F	do	do	Do.
Cameron mine powder No. 3–A	Class 4	do	Do.
Carbonite No. 1	do	do	E. I. du Pont de Nemours Powder Co., Wilmington, Del.
Carbonite No. 2	do	do	Do.
Carbonite No. 3	do	do	Do.
Carbonite No. 4	do	do	Do.
Carbonite No. 5	do	do	Do.
Carbonite No. 6	do	do	Do.
Coalite A	Class 1*a*	do	Potts Powder Co., New York, N. Y.
Coalite X	do	do	Do.
Coalite No. 1	Class 4	do	Do.
Coalite No. 2–D	do	do	Do.
Coalite No. 2–D. L	do	do	Do.
Coalite No. 2–M, L. F	do	do	Do.
Coalite No. 3–X	Class 1*a*	do	Do.
Coalite No. 3–XA	do	do	Do.
Coalite No. 3–XB	do	do	Do.
Coalite No. 3–XC	do	do	Do.
Coal Special No. 1	Class 4	do	Keystone National Powder Co., Emporium, Pa.
Coal Special No. 2	do	do	Do.
Coal Special No. 2–W	do	do	Do.
Coal Special No. 3–C	do	do	Do.
Collier powder B, N. F	Class 1*a*	do	Do.
Collier powder KN	do	do	Do.
Collier powder No. X	do	do	Do.
Collier powder X, L. F	do	do	Do.
Collier powder No. 2	Class 4	do	Do.
Collier powder No. 5	Class 1*a*	do	Do.
Collier powder No. 5–L. F	do	do	Do.
Collier powder No. 5, special	do	do	Do.
Collier powder No. 6–L. F	Class 4	do	Do.
Collier No. 9	Class 1*a*	do	Do.
Collier powder No. 11	do	do	Do.
Cronite No. 1	do	do	G. R. McAbee Powder & Oil Co., Pittsburgh, Pa.
Cronite No. 5	do	No. 7	Do.
Detonite special	do	do	The King Powder Co., Cincinnati, Ohio.
Eureka No. 2	Class 2	No. 6	G. R. McAbee Powder & Oil Co., Pittsburgh, Pa.
Fort Pitt mine powder No. 1	Class 4	do	Fort Pitt Powder Co., Pittsburgh, Pa.
Fuel-ite No. 1	do	do	Burton Powder Co., Pittsburgh, Pa.
Fuel-ite No. 2	do	do	Do.
Fuel-ite No. 3	Class 1*a*	do	Do.
Giant A low-flame dynamite	Class 2	do	Giant Powder Co. (Consolidated), Giant, Cal.
Giant B low-flame dynamite	do	do	Do.
Giant C low-flame dynamite	do	do	Do.
Giant coal-mine powder No. 5	Class 1*a*	do	Do.
Giant coal-mine powder No. 6	Class 2	do	Do.
Giant coal-mine powder No. 7	do	do	Do.
Giant coal-mine powder No. 8	do	do	Do.

TABLE 1.—*Permissible explosives tested prior to Mar. 1, 1913*—Continued.

Brand.	Class designation.	When used with detonators, preferably electric detonators, of not less efficiency than—	Manufacturer.
Guardian A	Class 4	No. 7	Independent Powder Co., Joplin, Mo.
Guardian No. 2	Class 1*a*.	No. 6	Do.
Guardian No. 3	do	do	Do.
Guardian coal powder B	Class 4	No. 7	Do.
Hecla No. 2	Class 1*a*.	do	E. I. du Pont de Nemours Powder Co., Wilmington, Del.
Kanite A	Class 1*b*.	No. 8	W. H. Blumenstein Chemical Works, Pottsville, Pa.
Lomite No. 1	Class 2	No. 6	G. R. McAbee Powder & Oil Co., Pittsburgh, Pa.
Meteor AXXO	do	do	E. I. du Pont de Nemours Powder Co., Wilmington, Del.
Mine-ite A	Class 4	do	Burton Powder Co., Pittsburgh, Pa.
Mine-ite A-2	do	do	Do.
Mine-ite B	do	do	Do.
Mine-ite B-2	do	do	Do.
Mine-ite No. 5-D	Class 1*a*.	do	Do.
Monobel No. 1	do	do	E. I. du Pont de Nemours Powder Co., Wilmington, Del.
Monobel No. 2	do	do	Do.
Monobel No. 3	do	do	Do.
Monobel No. 4	do	do	Do.
Monobel No. 5	do	do	Do.
Monobel No. 6	do	do	Do.
Monobel No. 7	do	do	Do.
Nitro low-flame No. 1	Class 4	do	Nitro Powder Co., Kingston, N. Y.
Nitro low-flame No. 2	do	do	Do.
Trojan coal powder H	Class 3	No. 6	Pennsylvania Trojan Powder Co., Allentown, Pa.
Trojan coal powder I	do	do	Do.
Trojan coal powder J	do	do	Do.
Tunnelite B	Class 1*a*.	do	G. R. McAbee Powder & Oil Co., Pittsburgh, Pa.
Tunnelite C	do	do	Do.
Tunnelite No. 5	Class 4	do	Do.
Tunnelite No. 6	do	do	Do.
Tunnelite No. 6-L. F	do	do	Do.
Tunnelite No. 7	do	do	Do.
Tunnelite No. 8	do	do	Do.
Tunnelite No. 8-L. F	do	do	Do.

The tests now prescribed as those a permissible explosive must have passed are those given on pages 302–3. But even the explosives that have passed those tests and are published as permissible explosives are to be considered as permissible explosives only when used under the following conditions:

1. That the explosive is in all respects similar to the sample submitted by the manufacturer for test.

2. That detonators—preferably electric detonators—are used of not less efficiency than those prescribed, namely, those consisting by weight of 90 parts of mercury fulminate and 10 parts of potassium chlorate (or their equivalents).

3. That the explosive, if frozen, shall be thoroughly thawed in a safe and suitable manner before use.

4. That the quantity used for a shot does not exceed 1½ pounds (680 grams), properly tamped with clay or other noncombustible stemming.

It must not be supposed that an explosive that has once passed the above-mentioned tests and has been published in lists of permissible explosives is thereafter to be considered a permissible explosive, regardless of its condition or the way in which it is used. Thus, for example, an explosive named in the permissible list, if kept in a moist place until it undergoes a change in character is no longer to be considered a permissible explosive. If used in a frozen or partly frozen condition, it is not when so used a permissible explosive. If used in excess of the quantity specified

(1½ pounds), it is not when so used a permissible explosive. And when the other conditions have been met, it is not a permissible explosive if fired with a detonator of less efficiency than that prescribed.

Moreover, even when all the prescribed conditions have been met, no permissible explosive should necessarily be considered as *permanently* being a permissible explosive, but any permissible explosive when used under the prescribed conditions may properly continue to be considered a permissible explosive until notice of its withdrawal or removal from the list has been officially published, or until its name is omitted from a later list published by the Bureau of Mines.

Furthermore, the manufacturers of a permissible explosive may withdraw it at any time when introducing a new explosive of superior qualities. And after further experiments and conferences the Bureau of Mines may find it advisable to adopt additional and more severe tests to which all permissible explosives may be subjected, in the hope that through the use of such explosives only as may pass the more severe tests the lives of miners may be better safeguarded.

CLASSIFICATION OF PERMISSIBLE EXPLOSIVES.

In Table 2 the permissible explosives are arranged in four classes, the rate of detonation of each explosive being given.

TABLE 2.—*Classes and rate of detonation of permissible explosives.*

Class and brand of explosive.	Rate of detonation in 1¼ by 8 inch cartridge.	
	Feet per second.	Meters per second.
CLASS 1.—AMMONIUM NITRATE.		
Subclass a.		
Ætna coal powder AA	7,880	2,403
Bental coal powder No. 1-A	7,690	2,343
Bental coal powder No. 2	4,750	1,447
Bituminite No. 5	9,120	2,782
Black Diamond No. 5	6,020	1,835
Cameron mine powder No. 1-A	10,950	3,339
Cameron mine powder No. 2-A	10,520	[a] 3,206
Cameron mine powder No. 2-A, L. F	10,950	3,338
Coalite A	8,870	2,705
Coalite X	9,000	2,745
Coalite No. 3-X	7,290	2,223
Coalite No. 3-XA	10,420	3,176
Coalite No. 3-XB	11,290	3,441
Coalite No. 3-XC	8,320	2,536
Collier powder B, N. F	10,950	3,338
Collier powder KN	11,610	3,539
Collier powder No. X	7,820	2,384
Collier powder X, L. F	9,990	3,047
Collier powder No. 5	8,280	2,524
Collier powder No. 5-L. F	9,370	2,858
Collier powder No. 5, special	8,330	2,541
Collier No. 9	6,690	2,040
Collier powder No. 11	11,680	3,561
Cronite No. 1	10,490	3,198
Cronite No. 5	8,090	2,466
Detonite special	10,840	[b] 3,305
Fuel-ite No. 3	8,590	2,620
Giant coal-mine powder No. 5	10,230	3,118
Guardian No. 2	8,980	2,738
Guardian No. 3	7,660	2,336
Hecla No. 2	13,990	4,264
Mine-ite No. 5-D	8,720	2,658
Monobel No. 1	11,700	3,568
Monobel No. 2	9,870	3,009
Monobel No. 3	7,260	2,212
Monobel No. 4	8,980	2,738
Monobel No. 5	6,760	2,061
Monobel No. 6	10,380	3,165
Monobel No. 7	10,050	3,065
Tunnelite B	9,990	3,047
Tunnelite C	10,060	3,068

[a] 1¾-inch cartridges used.

[b] 1¾-inch cartridges used.

TABLE 2.—*Classes and rate of detonation of permissible explosives*—Continued.

Class and brand of explosive.	Rate of detonation in 1¼ by 8 inch cartridge.	
	Feet per second.	Meters per second.
CLASS I.—AMMONIUM NITRATE—Continued.		
Subclass b.		
Kanite A	10,730	[a]3,270
CLASS 2.—HYDRATED.		
Eureka No. 2	10,720	3,269
Giant A low-flame dynamite	8,140	2,481
Giant B low-flame dynamite	9,100	2,773
Giant C low-flame dynamite	8,860	2,702
Giant coal-mine powder No. 6	11,540	3,519
Giant coal-mine powder No. 7	10,830	3,301
Giant coal-mine powder No. 8	10,830	3,301
Lomite No. 1	13,940	4,250
Meteor AXXO	8,410	2,563
CLASS 3.—ORGANIC NITRATE (OTHER THAN NITROGLYCERIN).		
Trojan coal powder H	9,420	2,872
Trojan coal powder I	9,620	2,934
Trojan coal powder J	10,590	3,230
CLASS 4.—NITROGLYCERIN.		
Ætna coal powder A	12,620	3,848
Ætna coal powder B	9,870	3,008
Ætna coal powder C	7,010	2,138
Bituminite No. 1	12,800	3,901
Bituminite No. 3	9,330	2,843
Bituminite No. 4	7,540	2,298
Black Diamond No. 2-A	12,600	3,842
Black Diamond No. 3-A	11,160	3,402
Cameron mine powder No. 3-A	10,930	3,333
Carbonite No. 1	10,950	3,338
Carbonite No. 2	11,380	3,470
Carbonite No. 3	8,710	2,656
Carbonite No. 4	7,670	2,339
Carbonite No. 5	10,140	3,092
Carbonite No. 6	7,490	2,285
Coalite No. 1	7,930	2,418
Coalite No. 2-D	8,430	2,571
Coalite No. 2-D. L	7,340	2,237
Coalite No. 2-M, L. F	9,220	2,811
Coal special No. 1	11,800	3,598
Coal special No. 2	10,240	3,123
Coal special No. 2-W	11,590	3,534
Coal special No. 3-C	9,760	2,977
Collier powder No. 2	8,870	2,704
Collier powder No. 6-L. F	9,660	2,944
Fort Pitt mine powder No. 1	11,230	3,424
Fuel-ite No. 1	11,150	3,400
Fuel-ite No. 2	8,240	2,512
Guardian A	10,130	3,089
Guardian coal powder B	8,960	2,733
Mine-ite A	11,290	3,443
Mine-ite A-2	10,670	3,252
Mine-ite B	9,540	2,908
Mine-ite B-2	7,410	2,260
Nitro low-flame No. 1	13,380	4,079
Nitro low-flame No. 2	14,560	4,439
Tunnelite No. 5	8,400	2,562
Tunnelite No. 6	9,670	2,947
Tunnelite No. 6-L. F	9,620	2,933
Tunnelite No. 7	8,720	2,659
Tunnelite No. 8	8,020	2,446
Tunnelite No. 8-L. F	8,720	2,658

[a] 1¾-inch cartridges used.

PUBLICATIONS ON MINE ACCIDENTS AND TESTS OF EXPLOSIVES.

The following Bureau of Mines publications may be obtained free by applying to the Director, Bureau of Mines, Washington, D. C.

Bulletin 10. The use of permissible explosives, by J. J. Rutledge and Clarence Hall. 1912. 34 pp., 5 pls., 4 figs.

Bulletin 15. Investigations of explosives used in coal mines, by Clarence Hall, W. O. Snelling, and S. P. Howell, with a chapter on the natural gas used at Pittsburgh, by G. A. Burrell, and an introduction by C. E. Munroe. 1911. 197 pp., 7 pls., 5 figs.

Bulletin 17. A primer on explosives for coal miners, by C. E. Munroe and Clarence Hall. 61 pp., 10 pls., 12 figs. Reprint of United States Geological Survey Bulletin 423.

Bulletin 20. The explosibility of coal dust, by G. S. Rice, with chapters by J. C. W. Frazer, Axel Larsen, Frank Haas, and Carl Scholz. 204 pp., 14 pls., 28 figs. Reprint of United States Geological Survey Bulletin 425.

Bulletin 42. The sampling and examination of mine gases and natural gas, by G. A. Burrell, 1912. 106 pp., 2 pls., 21 figs.

Bulletin 44. First national mine-safety demonstration, by H. M. Wilson and A. H. Fay, with a chapter on the explosion at the experimental mine, by G. S. Rice. 1912. 75 pp., 7 pls., 4 figs.

Bulletin 46. An investigation of explosion-proof motors, by H. H. Clark. 1912. 44 pp., 6 pls., 14 figs.

Bulletin 48. The selection of explosives used in engineering and mining operations, by Clarence Hall and S. P. Howell. 1912. 50 pp., 3 pls., 7 figs.

Bulletin 51. The analysis of black powder and dynamite, by W. O. Snelling and C. G. Storm. 1913. 80 pp., 5 pls., 5 figs.

Bulletin 52. Ignition of mine gases by the filaments of incandescent electric lamps, by H. H. Clark and L. C. Ilsley. 1913. 31 pp., 6 pls., 2 figs.

Bulletin 56. First series of coal-dust tests in the experimental mine, by G. S. Rice, L. M. Jones, J. K. Clement, and W. L. Egy. 1913. 115 pp., 12 pls., 28 figs.

Bulletin 59. Investigations of detonators and electric detonators, by Clarence Hall and S. P. Howell. 1913. 79 pp., 10 pls., 5 figs.

Bulletin 62. Record of the national mine-rescue and first-aid conference, Pittsburgh, Pa., September 23–26, 1912, by H. M. Wilson. 1913. 74 pp.

Bulletin 65. Oil and gas wells through workable coal beds; papers and discussions, by G. S. Rice, O. P. Hood, and others. 1913. 101 pp., 1 pl., 11 figs.

Technical Paper 4. The electrical section of the Bureau of Mines, its purpose and equipment, by H. H. Clark. 1911. 12 pp.

Technical Paper 6. The rate of burning of fuse as influenced by temperature and pressure, by W. O. Snelling and W. C. Cope. 1912. 28 pp.

Technical Paper 7. Investigations of fuse and miners' squibs, by Clarence Hall and S. P. Howell. 1912. 19 pp.

Technical Paper 11. The use of mice and birds for detecting carbon monoxide after mine fires and explosions, by G. A. Burrell. 1912. 15 pp.

Technical Paper 12. The behavior of nitroglycerin when heated, by W. O. Snelling and C. G. Storm. 1912. 14 pp., 1 pl., 2 figs.

Technical Paper 13. Gas analysis as an aid in fighting mine fires, by G. A. Burrell and F. M. Seibert. 1912. 16 pp., 1 fig.

Technical Paper 14. Apparatus for gas-analysis laboratories at coal mines, by G. A. Burrell and F. M. Seibert. 1913. 24 pp., 7 figs.

TECHNICAL PAPER 17. The effect of stemming on the efficiency of explosives, by W. O. Snelling and Clarence Hall. 1912. 20 pp. 11 figs.

TECHNICAL PAPER 18. Magazines and thaw houses for explosives, by Clarence Hall and S. P. Howell. 1912. 34 pp., 1 pl., 5 figs.

TECHNICAL PAPER 19. The factor of safety in mine electrical installations, by H. H. Clark. 1912. 14 pp.

TECHNICAL PAPER 21. The prevention of mine explosions; report and recommendations by Victor Watteyne, Carl Meissner, and Arthur Desborough. 12 pp. Reprint of United States Geological Survey Bulletin 369.

TECHNICAL PAPER 23. Ignition of gas by miniature electric lamps, by H. H. Clark. 1912. 5 pp.

TECHNICAL PAPER 24. Mine fires, a preliminary study, by G. S. Rice. 1912. 51 pp., 1 fig.

TECHNICAL PAPER 28. Ignition of mine gas by standard incandescent lamps, by H. H. Clark. 1912. 6 pp.

TECHNICAL PAPER 29. Training with mine-rescue breathing apparatus, by J. W. Paul. 1912. 16 pp.

TECHNICAL PAPER 40. Metal-mine accidents in the United States during the calendar year 1911, compiled by A. H. Fay. 1913. 54 pp.

TECHNICAL PAPER 44. Safety electric switches for mines, by H. H. Clark. 1913. 8 pp.

TECHNICAL PAPER 46. Quarry accidents in the United States during the calendar year 1911, compiled by A. H. Fay. 1913. 32 pp.

TECHNICAL PAPER 47. Portable electric mine lamps, by H. H. Clark. 1913. 13 pp.

TECHNICAL PAPER 48. Coal-mine accidents in the United States, 1896–1912, with monthly statistics for 1912, compiled by F. W. Horton. 1913. 74 pp. 10 figs.

TECHNICAL PAPER 52. Permissible explosives tested prior to March 1, 1913, by Clarence Hall. 1913. 11 pp.

MINERS' CIRCULAR 3. Coal-dust explosions, by G. S. Rice. 1911. 22 pp.

MINERS' CIRCULAR 4. The use and care of mine-rescue breathing apparatus, by J. W. Paul. 1911. 24 pp., 5 figs.

MINERS' CIRCULAR 5. Electrical accidents in mines; their causes and prevention, by H. H. Clark, W. D. Roberts, L. C. Ilsley, and H. F. Randolph. 1911. 10 pp., 3 pls.

MINERS' CIRCULAR 6. Permissible explosives tested prior to January 1, 1912, and precautions to be taken in their use, by Clarence Hall. 1912. 20 pp.

MINERS' CIRCULAR 9. Accidents from falls of roof and coal, by G. S. Rice. 1912. 16 pp.

MINERS' CIRCULAR 10. Mine fires and how to fight them, by J. W. Paul. 1912. 14 pp.

MINERS' CIRCULAR 11. Accidents from mine cars and locomotives, by L. M. Jones. 1912. 16 pp.

MINERS' CIRCULAR 12. The use and care of miners' safety lamps, by J. W. Paul. 1913. 16 pp., 4 figs.

MINERS' CIRCULAR 15. Rules for mine-rescue and first-aid field contests, by J. W. Paul. 1913. 12 pp.

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